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MINERAL WATERS AND SPAS

OF

NEW ZEALAND.

ARTHUR S. WOHLMANN, M.D., B.S., Lond.,

GOVERNMENT BALNEOLOGIST.

THE

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BY

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PREFACE.

With the constant advance of knowledge, and the consequent incessant recrystallization of our ideas, the medical world is embarrassed with an ever-increasing flood of literature. So great is this flood that one feels that some very good excuse indeed is needed before one adds even a single drop to the ocean of verbiage. There can be only two excuses — either something new can be told, or something old can be put more clearly than it has been put before. I hold myself especially fortunate in that, to a great extent, I can avail myself of the former pretext and can claim the privileges of the pioneer. Beyond a small pamphlet by Dr. Ginders, published some fifteen years ago, dealing with the waters of Rotorua and Hanmer before those spas were to any extent developed, there has been, so far as I am aware, no work dealing with the mineral waters of New Zealand from a medical point of view.

In 1902 I was engaged by the Government of New Zealand to advise in the development of the mineral-water health resorts of the country, and this has been my work ever since.

Owing to the immense number of springs and the comparatively sparse population, it was obviously impossible to devote equal attention to every spring, or even to every valuable spring, for this would be to dot the country with a host of half-developed spas of little practical utility, and I advised rather the concentration of effort on one or two. This policy has been adhered to; so that now there are one first-class spa (Rotorua), two second-class (Hanmer and Te Aroha), and for the rest little has been done. It need hardly be added that this has not been a policy altogether popular with those districts whose claims have been rejected, but that it has been the right policy I have no shadow of doubt.

Some years ago a small book of mine was published by the Government to serve as a guide to the different spas of New Zealand. This little book, which was written rather from a popular point of view, has now run through several editions,

and fulfils, I believe, the purpose for which it was conceived. There being no work, however, dealing with the subject from the strictly medical standpoint, the purpose of these pages is to supply the deficiency. An endeavour has been made to give the medical profession precise and detailed information about the equipment and the limitations of the various spas of this country, so that practitioners may know not only what mineral waters are to be found at each place, but exactly what kind of equipment is available for the treatment of their patients.

The old system of classification of mineral waters according to their chemical composition has been retained, as it would seem to be that most generally understood and useful; and it will be noted that several of the waters, such as those containing sulphuric acid in large quantity and the borated waters, are unfamiliar in mineral-water treatment.

Balneology as an exact science being yet in its infancy, and being as yet almost untaught in the medical schools, is naturally a subject somewhat outside the purview of the busy general practitioner, and it will be conceded that a good deal of misconception, as well as a good deal of healthy scepticism, exists about the whole subject. Bearing this in mind, it would seem that no further apology is needed for including in the subject-matter some account of the main principles of balneology and of physical treatment generally, in so far—but only in so far—as they are concerned with the actual methods practised in our spas. At the same time, while fully admitting that medicine is yet an art rather than an exact science, an attempt has been made to demonstrate, by reference to the published researches of others, as well as to my own experimental work and investigations, to what a large extent balneology is based on rational as opposed to empirical principles.

Inseparably bound up with balneological treatment is the question of dietetics, and a chapter on this subject in so far as it touches spa practice has been included.

If at times complex problems have been handled somewhat dogmatically, it must be advanced in extenuation that this work makes no pretence to being a text-book of balneology, of dietetics, or of physical treatment, but a plain and simple

account of treatment as it is at present practised at our spas. With the same end in view, there is a short chapter dealing with clinical work at Rotorua, the spa with which I have been most intimately connected.

In dealing, in the clinical chapters, with the somewhat nebulous class of so-called "rheumatic" diseases, it will be noticed that a departure has been made from the system of nomenclature hitherto considered orthodox. Assuming that acute rheumatism is caused by an infection by micro-organisms, and is a specific disease running a more or less definite course, the term "chronic rheumatism" has been almost eliminated, and the great bulk of cases usually labelled under that heading have been put down as gout. This is only a provisional and makeshift device, as doubtless many of the cases of auto-intoxication with "rheumatic" symptoms are caused by other agents than uric-acid salts, and, indeed, the recent developments of vaccine therapy have conclusively proved this to be the case; still it is convenient, and as long as it it is clearly understood that the classification is provisional, and only awaiting an improved nomenclature, it seems more scientific to class the undefined intoxications with a gouty condition, into which they insensibly merge, than with an acute specific fever like rheumatism, from which they are obviously differentiated.

In conclusion, a word of apology is needed in regard to the incompleteness of the list of the references to authorities. A private library is somewhat meagre, and complete verification of all references has been exceedingly difficult; but those who have lived for ten years remote from a good medical library will understand the difficulties, and, understanding, will, I trust, condone the deficiencies.

ARTHUR S. WOHLMANN.

Rotorua, New Zealand.

The Mineral Waters and Spas of New Zealand.

CHAPTER I.

BALNEOLOGICAL TREATMENT.

BALNEOLOGICAL treatment, while useful in a limited number of sub-acute conditions, is indicated more especially in *chronic* disease —chronic affections of the joints, of the circulatory system, of the nervous system, of the digestive tract, and of the skin, and in cases of chronic auto-intoxication generally. It is also of special service in those numerous cases in which the condition displays so slight a departure from the normal, or perhaps it would be more correct to say so subtle a departure from the normal, that one cannot label the illness, and indeed hesitates to apply the term "disease" at all. Yet, just as measles, taken in the aggregate, is a more serious menace to the white race than, say, plague, so these subtle and apparently trivial departures add perhaps more to the sum total of human misery and human inefficiency than do the more dramatic departures from health, which we docket as distinct diseases. If one takes a dispassionate survey of the whole realm of medicine and surgery, it will be at once conceded that acute disease tends to monopolize the attention of our profession; that the keenest interest and the most determined effort are called forth by the acute case; that when a case degenerates into the chronic stage interest speedily declines, and the fight with disease is carried on in but half-hearted fashion. It is natural, and perhaps inevitable, that this should be so. To a minor degree we see the same thing in the rivalry between medicine and surgery: the direct methods, the tangible and often brilliant results of the surgeon, appeal to an ever-increasing army of aspirants.

But however improved our methods, however brilliant our results, there still remains that great multitude of chronic sufferers for whom treatment still seems so depressingly impotent—the great, dull, hopeless mass that eventually fills the workhouse infirmaries or saddens and cripples countless households. Apart altogether from the point of view of the individual sufferer, however, the economic feature is one of the

utmost importance. The man or woman of forty crippled by chronic disease to a premature old age of work sterility is a loss of earning-power as well as a direct burden upon the community at large, and no effort can be too great, no sacrifice too heavy, which will lighten this burden. Apart from hygienic and preventive measures, balneological treatment, conjoined with physical treatment generally, is the most potent therapeutic weapon at our disposal for combating this evil.

Spa Treatment.—Until comparatively recent years spa treatment has been largely, if not wholly, empirical, and, while universal experience has proved its beneficial results, how and to what extent the mineral water as such has been the responsible factor have been questions discussed with some scepticism.

Before proceeding to consider the mineral-water health resorts of this country let us first examine the principles on which balneological treatment rests, and the more thoroughly and carefully we examine this method of treatment the more clearly we shall see that it has a rational basis—that it rests on physiological data, on laws whose working we can follow and whose results we can forecast.

As we examine the phenomena we shall see that the treatment is essentially an *alterative* one — that all its processes are conceived with the one fundamental idea of influencing metabolism ; and if we hold, as it would seem we almost necessarily must hold, that at any rate the vast bulk of chronic disease is due to chronic abnormality of metabolism, such treatment is most clearly indicated.

The principal factors in a cure at a watering-place are,—

(1.) Mineral-water treatment.
(2.) Accessory physical treatment.
(3.) Diet and regulation of habits.
(4.) Change of environment.
(5.) Suggestion.

MINERAL-WATER TREATMENT.

Mineral-water treatment may be internal, by mouth administration, or external, by various forms of baths and douches ; as a general rule both methods being employed simultaneously.

The question at once arises as to how much of the result may be attributed to the water as such, to hydrotherapy, and how much to the mineral water in virtue of its ingredients. Further,

what difference, if any, exists between a solution of salts prepared by the chemist in distilled water and a similar solution obtained from a mineral spring.

Until recently the saline, and to some extent the gaseous, contents of mineral waters have alone been considered in comparative analyses, and, unless we are to recant all our belief in the efficacy of drugs, the importance of these ingredients, at any rate in internal administration, is obvious. Recent developments of science, however, have profoundly modified our whole conception of matter, and it is now realized that the question is much more complex than hitherto assumed, and that certain heretofore unsuspected physical conditions of liquids may prove of importance equal, or more than equal, to the gross chemical ones revealed by ordinary analysis. A great proportion of the profession, if asked, would say that an artificial mixture of salts in water would have the same physiological results as an apparently identical solution of mineral water. Spa physicians have always denied this, but their denial, unsupported by scientific argument except that of clinical experience, has been naturally attributed to interested motives or to a prejudice little removed from superstition. Whatever ground they may have had for this belief, the results of modern research show that there are other factors to be taken into consideration, and tend more and more to confirm those of clinical experience. We are still groping in the twilight of half-accepted theories and half-understood experiments, and the time is not yet ripe for dogmatism. But meantime we may consider some of the possible factors in the problem, so far as we have yet grasped them.

Freshness of Water.—Fortesque Fox* draws attention to the importance of the quality of "freshness" in water, and quotes Armand Gautier's views on the "endogenous" formation of the water in certain mineral springs from igneous rocks. As is well known, even the deepest igneous rocks contain imprisoned intimately in their substance minute particles of water, which give them a crystalloid structure. On ejection of the rock as lava, and the consequent release of pressure, this water bursts into steam, with the concomitant transformation of the almost hyaline lava into spongy pumice.† It is this water, formed as it were *de novo*

* Roy. Soc. Med. Balneol. Sec., May 15, 1911.

† This has been for many years the accepted explanation of the source of volcanic explosive energy and of the formation of pumice. Recently, however, Brun ("Recherches sur l'exhalaison volcanique") would appear to have upset the orthodox theory by his researches. He shows that, when "active" unoxidized volcanic rocks are heated to a certain temperature, gas and volatile salts are given off with explosive violence (1 kilog. of

and independent of surface rainfall, which is looked upon as the supply of geysers and deep volcanic springs, and it is suggested that this " virgin water " has special solvent and other properties.

This quality of " freshness " may be due to ionization, to radio-activity, to the presence of gases in the water, or to some other as yet undiscovered and unstable condition. To whatever cause it may be due, long experience has absolutely convinced me of its paramount importance in mineral-water as distinguished from plain-water therapy.

Ionization. — A salt dissolved in water appears to undergo, apart from its mere solution, more or less profound chemico-physical modification. A large proportion of its molecules are dissolved as such (electrically neutral molecules), but a certain proportion split up into smaller electrically charged radicles or ions, which are quite distinct from atoms, and may consist either of homogeneous atoms or of groups of combined and dissimilar atoms. These ions carry, some a charge of positive electricity—electro-positive ions; others a negative charge—electro-negative ions. Such a solution is a good electrical conductor or electrolyte. If now a " constant current " be passed between electrodes through the electrolyte, these ions may be collected, the electro-positive ions seeking the negative electrode or cathode, and being hence known as " cations," while the electro-negative ions are repelled from the cathode and seek the anode, and are termed " anions." Metals and the ions of alkaloids are " cations," acid radicles and the hydroxyl ions of alkalies " anions." The degree to which this splitting-off of ions takes place, or the " degree of dissociation," varies under different circumstances. Other conditions being equal, the weaker the solution the greater the proportion of free ions,* and the ionization of certain mineral waters is believed to be more complete than that of a corresponding artificial solution of salts, and that of weakly mineralized mineral waters than that of stronger waters.† The importance of these free ions from a therapeutic standpoint is very great; indeed, to quote Leduc,‡ " The majority of chemical, toxic, and therapeutic actions of electrolytic solutions are ionic in nature, . . . and the majority of drugs given

Krakatoa obsidian yielding 1,577 c.c. of gas at 800° C.), and to this action he attributes volcanic outbursts and the formation of pumice. He shows that water vapour is largely dissipated at 150° C., and wholly so at 300° C. While he asserts that volcanic explosive eruptions are anhydrous, he maintains that solfatara owe their aqueous character to the invasion of partially cooled volcanic rocks by superficial waters.

* Compare the teachings of homœopathy.

† Compare the radio-activity of weak mineral waters.

‡ Leduc, " Ionic Medication," Med. Annual, 1912.

by the mouth owe their activity to ions. For example, we prescribe solutions of potassium-iodide, which contain electrically neutral molecules KI, electro-positive ions K—, electro-negative ions I—. It is to these last that all the activity is due, and it is proportional to their concentration."

Solutions capable of conducting electricity are known as electrolytes, and, as we have already seen, solutions containing many free ions are good conductors; indeed, the degree of ionization of a mineral water may be measured, other conditions being equal, by its degree of conductivity.

Radio-activity.—The widespread presence of radium in nature is now recognized, and its presence in mineral-water springs might naturally be expected; indeed, the largest and most important body of mineral water in the world—the ocean—is distinctly radio-active.

Radio-activity may be due to the presence of actual radium salts in the water, or to emanation taken up by the water in its passage past insoluble radium compounds, the latter being the more frequent and important variety. Thus, most deep cold springs show radio-activity due to emanation; and this quality may be so pronounced as to affect photographic plates (skotography). This emanation decays at a certain rate in accordance with well-known laws, and, unless dissolved radium salts are also present, activity ceases in a few weeks.*

That the quality of "freshness" is lost long before the serious decay of the emanation would point to its being due, at any rate partially, to some other factor.

Osmotic Pressure or Tension.—"Dissolved substances behave like gases or vapours, spreading through the solvent with a certain measurable 'osmotic pressure,' which follows the same laws and has the same physical constants as in the case of gases and vapours, being, as in these cases, proportional to the molecular concentration—*i.e.*, to the number of molecules dissolved in a litre of solution. The osmotic pressure is measured by cryoscopy—*i.e.*, by the lowering of the freezing-point of the solution in relation to that of pure water, this lowering being proportional to the molecular concentration. In solutions conducting electricity the freezing-point is always lower and the osmotic pressure greater than the molecular concentration would indicate, because of the dissociation of molecules into ions which, from the point of view of the osmotic pressure and freezing-point, behave like independent molecules."†

* Chapter V. † Leduc, "Ionic Medication," Med. Annual, 1912.

Mineral waters may be divided, according to their osmotic pressure, into a hypertonic group, whose pressure is higher than that of the blood; an isotonic group, whose pressure is about the same as that of the blood; and a hypotonic group, whose pressure is distinctly lower than that of the blood; and from what has already been said as to the comparative richness in ions of some mineral waters, it will be seen that the osmotic pressure of a mineral water may be higher than that of a corresponding artificial solution of salts. The question of the osmotic pressure of a mineral water is evidently of some importance when the water is given internally,* though it is difficult to see how it can appreciably be effective in the form of baths.

Gases contained in Mineral Water.—The stimulating properties on the skin of CO_2 gas bubbling through a bath have long been known and appreciated, and have sufficed to give the carbonated saline waters of Nauheim a world-wide reputation. In New Zealand there is a fierce evolution of this gas through the calcareous chalybeate waters of Kamo,† and a mild effervescence in some of the Priest‡ waters at Rotorua. Other gases have a similar though less marked effect, and oxygen baths, which are said to have a more calmative result, have been extensively used of recent years.

The indifferent temperature of water—that is, the temperature at which it ceases to stimulate the skin by either heat or cold—is from 93° to 99° F., while that of gases is much lower, that of air being 68° to 77° F., and of other gases lower still. It is for this reason that a cooler bath can be taken without a feeling of chilliness when CO_2 is bubbling through the water than in an ordinary bath in which no CO_2 is present. Thus a CO_2 charged bath at 90° F. feels at first cool, but as the gas-bubbles begin to collect on the skin, and form a badly conducting layer on it, there comes gradually a sensation of warmth, for the gas being at 90° F. is well above its indifferent temperature, and therefore feels warm.

In many of the New Zealand baths other gases, such as N, H, H_2S, and CH_4, are abundant.

It is yet doubtful what, if any, effect the gases exert,§ but it is

* A water hypertonic as regards blood plasma, if it acts on the bowels at all, does so as a stimulating flush without being itself absorbed. (F. A. de T. Mouillot, Bal. Sec., Roy. Soc. Med., Nov. 1913.)

† *Cf.*, pp. 137–38.

‡ *Cf.*, pp. 80–81.

§ Even nitrogen may under certain circumstances lose its chemical inertness and become highly active. The experiments of the Hon R. J. Strutt show that by the passage of a stream of high tension discharges through the rarefied gas, nitrogen may assume a monatomic form, comparable to it as ozone to oxygen. We have yet much to learn about the physical properties of the gases arising through mineral springs.

probable that they have some definite action, and constitute the difference in " feel " between a fresh and a stale water.

The question arises as to the relative efficacy of natural and artificial gaseous baths. Gases bubbling through long columns of water become ionized, and it is reasonable to suppose that an ionized gas acts more energetically than one not ionized. So that here again the preference of clinical experience is confirmed.

Again, where mixed gases are evolved, fresh chemical combinations are formed, as in the acid waters of Rotorua, where SO_2, CO_2, and H_2S bubble up in the water, with a deposition of nascent sulphur. The same occurs in the Sulphur Vapour bath at Rotorua, which consists principally of SO_2 and hot steam, and in which nascent sulphur is deposited on the skin of the bather. Nobody who has experienced these baths can doubt the peculiar pungency of their skin-stimulation, and I believe this to be in part due to the nascent condition of the stimuli.

Effect of Plain Water.—To consider now the other point—the relative efficacy of water and mineral water.

Pure distilled water drunk in large quantities is said to be not only a direct irritant to the gastric mucous membrane, but the tendency to osmotic equilibrium may theoretically produce a draft on distant cells.*

The efficacy of plain water—that is, mildly mineralized water—for washing out the stomach and for flushing the urinary tract is of course obvious, while the physiological effects of hot and cold water on the internal organism *via* skin-stimulation have been worked out thoroughly and systematically, and form the basis of modern hydrotherapy and balneology. How much, however, can be attributed to the mineral ingredients apart from the water as such ?

There are some mineral waters, including some of the most world-famous, classified as " indifferent or simple thermal waters," so poor in mineral ingredients that before the days of radium practically the whole of their action has been put down to the hot water ; but there are many others whose mineral-content is so important that it would be quite impossible to put it on one side as a negligible therapeutic agent, and some of the most notable of these waters arise in New Zealand.

Of course, when administered by the mouth, no one can question the potency of the dissolved salts ; but their general action on the organism by medium of the unbroken skin in a bath is not

* *Cf.* Amer. Journ. Physiologic Therapeutics, Vol. i, No. 5 ; also O. Liebrich, quoted by Weber—" Climatotherapy and Balneotherapy."

at first sight quite so evident, for the skin is not normally permeable to water, mineral or otherwise.

Action on the Skin.—It is the various chemical, thermal, and mechanical stimuli of the mineral water acting on the skin which reflexly influence the whole organism; and how potent these stimuli, and how far-reaching their reflex effects, is a phenomenon as surprising as it is fascinating to investigate. The potential importance of the skin as a modifier of metabolism is, I think, not fully appreciated, and certainly is not adequately taught in the ordinary course of medical instruction.

Any one can see, without further argument, the significance to the whole organism of any modifications of function of a great internal organ like the liver, but one is apt to forget that the skin is not merely a mechanical protective covering of the body, but a true glandular organ, and a huge one. It is spread out thinly, and so does not fit our mental conception of an organ; but if we conceive it, with all its multitude of glands, ducts, capillaries, and nerve-endings, as rolled or folded up into a compact mass and tucked away inside the body, we see what an important organ it really is. Being designed essentially to react to external stimuli, instead of its organic potentialities being diminished by being spread out in a thin layer, these are really greatly increased, and in equal measure are increased our facilities for directly influencing it by therapeutic stimuli.

The dermal structures we are most concerned with are the sweat-glands, the nerve-endings, the capillaries. By influencing one or all of these three we can influence—(1) The body temperature, and by it general metabolism; (2) the amount of liquid withdrawn from the body, and so the process of osmosis in the body generally, and the amount of liquid excretory work thrown on the kidneys; (3) the excretion of toxic substances by the skin; (4) the vascularity of the skin, and reflexly the vascularity of internal structures, thereby profoundly influencing both the blood-pressure and metabolism generally; (5) the actual constitution of the blood, as will be shown later, not only as regards its plasma density, but as regards the number of erythrocytes and leucocytes—the importance of this influence on the body generally is obvious; (6) the nerve-endings, and reflexly every part of the nervous system, including the sympathetic, and, incidentally, the metabolism of almost any or every structure as desired.

As already stated, no attempt will be made here to write a formal treatise on balneology, and the above phenomena will be dealt with as shortly as possible, and only explained in so far as is necessary to give a grasp of the principles involved in the rational practice of hydro-therapeutics.

1. **The Body Temperature.**—Metabolism is retarded in cooled tissues, and within certain limits increased in warmed ones. This obtains when the cooling or warming is continuous, with a rapid alternation of the two, other factors enter, as will be seen in dealing with " reaction." Also, it must be remembered that moderate cooling of the surface causes increased internal bodily heat-production, more especially in the muscles, and that this heat-production takes place principally at the expense of the non-nitrogenous substances.

As moderate heating of the skin acts in the converse manner, we have a definite, if limited, command over hydro-carbon and carbo-hydrate metabolism. The increased muscular tone after a cold bath, and the diminished tone after a warm one, are familiar to all.

Practically, we can heat the tissues beyond the skin-layer either locally, as in a local vapour or hot-air bath, or, generally, in a complete vapour or immersion bath ; or still more deeply by the more penetrating radiant heat rays, or by certain electrical currents. It is so well recognized that the heat-regulating mechanism of the body does not fail us under ordinary circumstances that we at once look for trouble if we find the body-temperature raised even 1 degree. Immersed in water the case is quite different : partly from the specific heat of the water, and partly from the putting out of action of the chief defences of the heat-regulating mechanism, a condition of artificial fever is brought about after a very few minutes of immersion to the neck in a hot bath.*

The degree of fever varies considerably with the individual. For instance, I took the mouth temperature of twenty chronic arthritic patients before and during a bath. The patients were immersed in the same large bath (Public Priest) to the neck. The heat of the bath was maintained throughout at its usual temperature of 104° F. Before the bath the records were all from 98° to 98·8° F. After ten minutes' immersion, the lowest temperature recorded was 99° F., the highest (in two cases) 101·6° F. I could discover no particular reason, condition of health, &c., to account for one man having a temperature nearly 3° higher than another. In a subsequent experiment similar results were obtained, but the highest pyrexia, also 101·6° F., occurred in a man whose temperature before the bath was already somewhat raised, 99·6° F.

Leonard Hill and Martin Flack,† experimenting on themselves and on students with immersion baths at 105° to 110° F., found

* In the hot vapour-saturated atmosphere of a Russian bath the temperature rises still more rapidly. Thus, twenty-five minutes' exposure to a temperature of 113° F. raised the body-temperature from 98·4° F. to 103·4° F. : Hinsdale, quoting Frey and Heilingenthals.

† Proc. Physiol. Soc., quoted B.M.J., May, 22, 1909, page 1255.

the body-temperature, after twenty minutes' immersion, to be raised to 102° to 104° F. As a result, in addition to the changes recorded here of cutaneous hyperæmia, lowered blood-pressure, and rapid pulse, they found that a condition of hyperpnœa ensued, and, as a consequence, the partial pressure of carbonic acid in the alveolar air was lowered from the normal 5 or 6 per cent. to 3 or 4 per cent., so that the body was not only cleansed of carbonic acid, but well oxygenated.

It is evident, then, that the raised bodily temperature consequent on immersion in hot baths is responsible for profound alterations of metabolism quite apart from any consideration of the special and peculiar effects which may be caused by the mineral-content of the water. Bearing in mind that the bulk of patients taking a course of hot baths are suffering from disorders of metabolism, the importance of this observation is evident.

The defensive mechanism of the body against microbic and toxic infection is also strengthened. Thus Rolly and Meltzer* found that phagocytic activity reached its maximum at about 104° F., declining again as the temperature rose to 106·7 F. Also, in rabbits kept for periods of from four to twenty days in a state of artificial pyrexia, the production of anti-toxins and agglutinins was accelerated, while the animals remained well and healthy, and no signs were found of the visceral parenchymatous changes so common in febrile pyrexia.

The possibility of another and more direct result of the artifical raising of the body-temperature has to be considered. It has been suggested that the natural febrile reaction consequent on microbic infection is part of the defensive mechanism of the body, the high temperature having bactericidal effects. This theory was based chiefly on the experiments of Pipping on the effect of fever temperatures on the growth of pneumococci in broth. Rolly and Meltzer,* however, pointed out how altered were the conditions when the organisms actually infected the body, and it would rather seem that a moderate general pyrexia, such as results from a hot bath, is only indirectly bactericidal by means of its already noted stimulant action on the defensive mechanism of the body.

The case of the extreme localized hyperpyrexia induced by a local hot-air bath—*e.g.*, to the knee, at 400° to 500° F.—or of a local vapour bath at 120° to 130° F. is quite different. I am not aware of any reliable records of the temperature of the interior of living joints under such conditions, but it is probable that it must be considerably raised, and it may possibly be so far raised as to either be directly germicidal or, at any rate, to so modify the

* Proc. Physiol. Soc., quoted B.M.J., May 22, 1909, page 1255.

culture medium of the patient's tissues as to prove inimical to the growth of micro-organisms (*cf.* action of radium, page 63).

To take the familiar case of a knee affected by gonococcic arthritis. The gonococcus is killed by an exposure of ten minutes to a temperature of 111° F., or immediately by a temperature of 113° F., and it is quite possible that temperatures approximating these may be set up in the synovial fringes and cavities of the knee-joint, and that where mischief is due to the actual multiplication of cocci in the joint, and not merely to circulating toxins, a localized bath may owe its efficacy to direct bactericidal action.*

At a spa we do not usually make use of the effects of general *cooling*, and the physiology of the process need not be discussed here. We do, however, use cold water, and very liberally, not so much for its general cooling effect, but in short sharp applications, as a stimulant to provoke reaction.

2. The Withdrawal of Liquid from the Body and the Excretion of Toxic Substances by the Skin.—These two functions can be conveniently treated together. The promotion of free sweating is one of the most ancient and universal aims of hydro-therapeutics. Of extreme value, it assumes perhaps an exaggerated importance in the public mind by its very simplicity and apparent directness of method, where much of treatment is intangible and indirect.

A hot bath stimulates the sweat-glands as part of the defensive armour of the heat-regulating centre. In addition, a bath containing irritating ingredients, such as the sulphuric-acid baths of Rotorua, by causing active hyperæmia of the skin, stimulates the glands yet more, so that a much more copious secretion of sweat takes place after a bath of Priest water than of plain water. The sweating, of course, begins in the bath, and is encouraged, if necessary, by a hot pack afterwards. Still more copious sweating ensues after a vapour bath, and reaches its acme, as might be expected, after a bath in which the steam is mixed with hot sulphurous-acid fumes, as in the Sulphur Vapour Bath at Rotorua.

The sweat, in addition to water and certain salts, contains fatty acids, carbonic-acid gas, certain obscure toxins and micro-organisms, and may contain appreciable and even large amounts of purin bodies, including uric acid ; so that hyperidrosis may not only relieve the work of the kidneys, but may even serve to excrete substances that would otherwise be permanently locked up in the system.† On the other hand, Beneke has shown that excessive

* It would appear, however, that somewhat higher temperatures can be withstood by the coccus within the tissues than when outside the body.

† It must be borne in mind that, in gout, uric-acid excretion by the kidney is usually diminished except during the attacks ; that this is essentially a disease of retention rather than of overproduction of urates.

sweating without a corresponding intake of water may so concentrate the urine that on the whole a diminution of the total excretion of nitrogenous substances results, an observation that shows the necessity of combining drinking the waters with taking thermal baths.

4. The Vascularity of the Skin, and reflexly the Vascularity of Internal Structures.—The immediate effect of a warm bath on the skin is to cause an apparently passive or atonic dilatation of the dermal arterioles and capillaries, due to diminished vasomotor influence and to the relaxation of the tissues surrounding the capillaries, venous congestion of the skin, and a somewhat lowered blood-pressure. As a result of this latter effect, there would be a tendency to general venous congestion, and little or no draining of deep organs. The immediate effect of a very hot* bath is closely similar to that of a cold one—viz., vasomotor constriction of the dermal arterioles, narrowing of the capillaries from increased tension of surrounding tissues, and possibly also from active contraction of their endothelial walls,† and increased blood-pressure. This effect, which is of comparatively short duration, is succeeded by the condition of skin hyperæmia already noted with a warm bath, but in much greater degree, and a condition of passive or atonic congestion of the skin results. With cold water, on the other hand, the primary contraction is followed, provided the immersion be not too long, by an active or tonic dilatation of the skin arterioles; the circulation is brisker, more blood goes through the skin, and, there being, if anything, an increased rather than a lowered blood-pressure, venous engorgement of internal organs is relieved, and there is, in fact, a glow of *bien être*—a reaction.

In certain hot mineral waters containing highly stimulating ingredients, such as the Priest water at Rotorua, which contains sulphuric and carbonic acids, *the second stage of passive relaxation is greatly delayed, and is preceded by a stage of active arteriole dilatation, such as is seen in the reaction after cold water.* This stage of active dilatation is of considerable duration, varying a good deal with the tonicity of the bather, and it is to this active stage that the acid waters of Rotorua largely owe their unique value. *They combine, in fact, many of the tonic properties of cold water with the pain-relieving properties of hot.*

After prolonged immersion, the secondary stage of relaxation asserts itself, and in the relief of painful conditions it is often advis-

* In New Zealand mineral baths are habitually taken at a higher temperature (up to 110° F.) than is usual in Europe.

† *Cf.* Baruch.

able to allow this stage to develop. Its advent, however, may be greatly delayed, if desired, by directing the patient to take a cold shower when half-way through his bath, and then to return to one still hotter.

One result of increasing the vascularity of the skin is frequently overlooked: I refer to the influence of hot mineral-water baths on skin-diseases. The beneficent result of certain baths in chronic skin-affections is such a matter of common experience as to be placed beyond all question; and while there is no doubt that bland mildly antiseptic solutions, like the alkaline silicate waters (compare page 73), may exert a specific action, yet I have seen quite remarkably good results in some cases from plain water. Patients suffering from chronic eczema, especially a chronic weeping eczema, are frequently warned to avoid much washing with water, and common experience confirms the wisdom of this advice. It is not the wetting, however, that is harmful, but the drying afterwards. Every person suffering from eczema, or even from a tender skin, is familiar with the stretched dry feeling that follows washing and drying the face after exposure to a cold wind. The skin feels as if it would crack with the tension, and, indeed, sometimes does crack. The necessarily short and intermittent wetting of the face possible in a mineral-water bath has the same effect, and I always consider baths contraindicated in skin-disease of the face. With prolonged immersion, however, such as is possible for the rest of the body, the case is different; for, apart altogether from the washing-away of epithelial debris, discharge, &c., or the possible effects of dissolved salts or of radio-activity, the influences of the liquid medium on the cutaneous nerve-endings and capillaries come into play, and their beneficial effects may more than outweigh the ill effects of the subsequent drying, especially if steps be taken to minimize those effects by coating the skin immediately after the baths with ointments or lotions.

Thus, prolonged immersion at an indifferent temperature—say, about 95° F.—may so soothe the cutaneous nerve-endings as to allay irritation and prevent scratching, while immersion at a higher temperature, such as 104° F., will cause a general hyperæmia of the skin. As a consequence of this latter there is a flooding of the affected area with plasma and phagocytes, the plasma activating the phagocytic process and neutralizing toxins. The tepid baths of Loéche probably owe their therapeutic efficacy to the former method, the hot Rachel baths, as used at Rotorua, largely to the latter.

Again, there is an intimate relation by vascular connection* between the blood-vessels of deeply seated organs and overlying

* Kellogg: Cohen's Syst. of Physiolog. Therap.

cutaneous vessels, a fact which gives a rational explanation of the value of counter-irritants (Treves).

By making a cold application over the reflex skin area and a hot application over the correlated vascular area, a very great alteration can be effected in the amount of blood flowing through a selected internal organ, a result which is enhanced by the effects of mechanical stimulation when a douch under pressure is used. A knowledge of these facts is at the basis of scientifically applied douching.

Again, it will be easily understood how a very hot bath, and especially a stimulating hot bath like the Priest at Rotorua, which provokes active as well as passive cutaneous hyperæmia, can very effectually drain congested abdominal viscera.

One of the risks, especially in cases of high blood-pressure and inelastic arteries, of entering a very hot bath is dangerous cerebral congestion. The Japanese,* before entering one of their very hot mineral baths (120° F.), kneel down and repeatedly pour hot water over the occiput. This causes primarily a reflex contraction of both the cerebral and scalp arteries, followed by a dilatation of the scalp arteries, and eventually, but not till considerable diversion of the blood-current from the deep vessels has taken place, by a dilatation of the cerebral vessels. This is often a more convenient procedure than an application of cold to the head, and I have used it in preference for some years past.

5. Changes in the Constitution of the Blood.†—These follow apparently as a natural corollary of phenomena described in the preceding paragraph. Apart from the ordinary effects of the relief of pain and stiffness observed after most thermal baths, one of the earliest clinical observations forced on my notice by the use of acid baths was the marked improvement in the general condition of the patients during a course, and more especially the very evident improved blood condition in many anæmic patients. Seeking for an explanation I recalled an observation of Winternitz‡ made as long ago as 1893, and since abundantly verified by a multitude of observers, including Rovighi,§ Strasser,‖ Knoepfelmacher,¶ and Magranti**: that after a cold bath, and more especially when skin-reaction was encouraged by stimulating measures

* *Cf.* Hinsdale: Hydrotherapy.

† Wohlmann: "The Acid Waters of Rotorua," N.Z. Med. Journ., Feb., 1911.

‡ "Blätter für Klinische Hydrotherapie," 1893; also his article in Cohen's "System of Physiologic Therapeutics."

§ International Congress, Rome (quoted by Baruch).

‖ "Blätter für Klinische Hydrotherapie," 1893.

¶ "Wiener Klinische Rundschau," 1894.

** Giornale della Reale Acad., Oct., 1895.

such as friction, douches, and vigorous muscular exercise, there was a decided increase of both red and white corpuscles in the cutaneous blood, the increase lasting generally about two hours. On the other hand, after a warm bath, there was a distinct decrease of both erythrocytes and leucocytes.

It is obvious that such a sudden increase of corpuscles—the results may be seen within ten minutes—could not be due to a fresh formation of cells. The suggestion has been made that these results may be due to the contraction of the surrounding tissues forcing the blood plasma out of the capillaries, and leaving some of the corpuscles stranded. Winternitz, however, explained the phenomenon, with, I think, more probability, as due to corpuscles being swept out of internal organs, where the blood was in a condition of comparative stasis, into the general circulation. This view was confirmed by a negative experiment of Breitenstein's,* who showed that when a rabbit was exposed to heat there was the same diminution of corpuscles in the cutaneous blood as is seen after a warm bath in man, with a simultaneous increase of corpuscles in the liver blood. Might not the explanation of the improvement of anæmic patients under a course of Priest baths lie in the close analogy between the physiological results on the cutaneous circulation of a cold bath of plain water and a hot bath of acid water?

Let us now consider what takes place after a bath in hot acid water, such as the Priest Bath at Rotorua. On first entering the bath there is a primary constriction of the vessels and a rise of blood-pressure. After a period, varying with the sensitiveness of the individual, but generally within a couple of minutes, the skin of the part immersed becomes bright red, almost scarlet, and of a tint quite different from that assumed by skin immersed in plain water of the same temperature. With this there is an absence of the sensation of relaxation familiar in an ordinary hot bath, and, indeed, in many persons a sensation of exhiliration is experienced. If the bather emerges after from five to ten minutes, and more especially if a momentary cold shower is taken, the sense of exhilaration is generally distinct. Omitting the cold shower, however, as a complicating factor, if a blood count be taken, it will be found that there is the same increase of both red and white corpuscles, as occurs after a short cold bath, and this increase, while sometimes only transient, may often be to a certain extent permanent, so that each bath may leave the patient with a blood count showing a slight increase on that of the previous one, in a manner suggestive of the rising temperature curve of a typhoid chart (*cf.* tables, p. 26). It would seem probable that, with the repeated sweeping-out of corpuscles from the stagnant

* Archiv. für Experim. Pathol. und Phar. Bd. 32, 1896.

by-ways into the broad highway of circulation, a certain proportion remain in the circulation, and that the functional effectiveness of the blood is thereby increased. The whole condition suggests a striking analogy to the *reactive* arterial hyperæmia seen after a short cold bath, and is in vivid contrast to the passive hyperæmia seen after a similar immersion in ordinary hot water, a dusky venous-looking flush. If, however, the immersion in the acid-water is prolonged, the reactive stage passes off and is succeeded by a condition of *passive* skin hyperæmia, with falling blood-pressure and a loss of muscular tone. Thus, by varying the time of immersion, we can accentuate either the reactive tonic hyperæmia where general tonic effects are desired, or the passive or atonic hyperæmia where relief of pain is the primary consideration ; or we can combine a short tonic immersion of the whole body with a prolonged immersion, and consequent atonic hyperæmia of, a small part—*e.g.*, the leg.

It will be seen that the local atonic hyperæmia so produced is strictly analogous to that caused by a poultice or a Bier's bandage. The physiological explanation of the contrasted tonic or active hyperæmia and the atonic or passive hyperæmia is still perhaps doubtful. The passive dilatation of arterioles as the result of withdrawal of vasomotor influence is of course familar, and it is possible that active hyperæmia may be caused by the reactive dilatation of arterioles after a preliminary vasomotor stimulation, a reaction the more marked the more violent the original stimulus. On this view tonic hyperæmia may be passive arterial dilatation, while atonic hyperæmia may be a passive venous congestion.

There is, however, another possibility. Some authors, notably Baruch,* have contended that, as a reflex result of skin-stimulation, there is an active dilatation of the arterioles as opposed to the passive relaxation that occurs as the withdrawal of vasomotor influence. Stimulation of the longitudinal muscular fibres of the arteries would actively dilate the vessels, while contraction of the circular fibres would narrow their lumen.† They also point out the observed rhythmic contraction of the arterioles of the rabbit's ear, the bat's wing, and the web of the frog's foot, a " skin-heart "‡

* " Principles and Practice of Hydrotherapy." Also compare Onimus : Gazette Med. de Paris, Oct. 15, 1898, on the autonomous movements of blood-vessels. Quoted by Weber : Balneotherapy.

† Exner., Acad. of Sciences, Vienna, 1877, pointed out the possibility of this by showing how the lumen of a stretched rubber tube was increased when its ends were approximated. It should be added, however, that longitudinal muscular fibres are found in the larger vessels only, arteries and veins.

‡ Baruch, also Woods Hutchinson, Boston Med. and Surg. Journal, Nov., 1907.

function analogous to that of the multiple hearts of some of the lower vertebrates—a function that would manifestly greatly aid the action of the central heart-pump. Assuming that similar phenomena occur in the arterioles of the human skin, it would appear at least probable that it is this rhythmic action which we stimulate when we cause active hyperæmia, and that it is this function which is the principal therapeutic agent in the Nauheim baths for dilated heart.

To sum up, it will be seen that owing to its peculiar stimulating effects on the cutaneous nerve-endings and, reflexly, on the cutaneous circulation the hot acid-sulphur waters combine some of the advantages of both hot* and cold water.

* *Short, very hot* baths, even of plain water, are stimulant. Knoepfelmacher ("Wiener Klinische Rundschau," 1894) demonstrated an increased blood count under these conditions.

Statistics of Blood Counts.

Note.—The blood was taken from the lobe of the ear, a part not actually immersed. Had it been withdrawn from the finger the results would probably have been more striking. (Compare the observations of Winternitz: System of Phys. Therap., Cohen.) The apparatus used was the Thoma-Zeiss Chamber, with Hayem's fluid as the medium for the red, and ½ per cent. methylene blue acetic acid for the white. To complete the table hæmoglobin estimations should also have been shown, but as these were unfortunately made in only four or five of the cases it was thought better not to include them, as a small number might be misleading. I would like here to acknowledge my indebtedness to former house-surgeons, Dr. Bertram and Dr. Hay, for much assistance in making blood counts.

Case.	Date.	Sex.	Disease.	Bath.	Temperature of Bath, Fahrenheit.	Time of Immersion.	Blood Count immediately before the Bath.	Blood Count after the Bath.	Time from End of Bath to Second Count.	Remarks.
1	14/10/09	F.	Rhoid arthritis	New Priest	104	15 min.	3,960,000	4,800,000	30 min.	
	15/10/09	,,	,,	,,	,,	,,	4,100,000	4,250,000	60 min.	
	16/10/09	,,	,,	,,	,,	,,	4,240,000	4,800,000	30 min.	
	22/10/09	..	,,	..	..	..	4,180,000	5,000,000	10 min.	
2	22/9/09	..	Rhoid arthritis	New Priest	104	15 min.	3,800,000	4,266,000	15 min.	
	6/10/09	..	..	..	..	..	4,200,000	4,800,000	,,	
3	..	M.	Rhoid arthritis	..	104	..	4,840,000	5,100,000	15 min.	
4	5/1/10	M.	Pernicious anæmia	New Priest	104	10 min.	1,230,000	1,000,000	30 min.	Patient also took arsenic and hæmatinics. Went down hill eventually, and died after pneumonia.
	6/2/10			..	..	,,	2,550,000	..	..	
	15/2/10			..	..	..	2,800,000	..	..	
	22/2/10			..	..	..	1,700,000	2,700,000	30 min.	
	25/2/10			New Priest	104	10 min.	1,600,000	1,600,000	10 min.	
	17/3/10			,,	,,	,,	1,560,000	1,600,000	,,	
5	15/3/09	F.	Rhoid arthritis	New Priest	104	15 min.	4,860,000	4,900,000	10–15 m.	
	22/3/09			,,	,,	,,	5,100,000	5,900,000	60 min.	
	30/3/09			,,	,,	,,	5,150,000	5,300,000	,,	
	3/4/09			..	..	..	5,600,000	5,200,000	½ hr.	

6	22/10/09	M.	Subacute rheumatism	New Priest	104	15 min.	5,400,000	5,600,000	30 min.	
	29/10/10			..	..	..	5,600,000	5,670,000	10 min.	
7	25/9/09	M.	Rhoid arthritis	New Priest	104	15 min.	Red, 4,000,000	Red, 4,300,000	15 min.	Nearly died from persistent bleeding after tooth-extraction. Has been gradually going down hill ever since leaving Sanatorium.
	..			..	..	..	White, 7,814	White, 8,750	..	
	28/9/09			New Priest	104	15 min.	Red, 4,000,000	Red, 4,400,000	..	
	..			,,	,,	,,	White, 7,184	White, 11,875	..	
	4/10/09			,,	,,	,,	Red, 3,700,000	Red, 4,800,000	..	
	..			..	..	..	White, 8,437	White, 8,437	..	
	13/10/09			New Priest	104	15 min.	4,800,000	5,600,000	..	
	28/10/09			,,	,,	,,	5,300,000	5,600,000	..	
	2/11/09			..	..	..	5,400,000	5,750,000	..	
8	18/9/09	F.	Subacute rheumatism	New Priest	104	15 min.	4,100,000	4,800,000	30 min.	
9	4/9/09	M.	Arthritis of spine	New Priest	104	15 min.	5,800,000	6,400,000	15 min.	
10	11/7/09	F.	Rhoid arthritis	Rachel ..	102–3	10 min.	5,100,000	4,900,000	15 min.	
11	22/5/10	M.	Convalescent Acute rheumatism	New Priest	104	..	5,833,000	6,400,000	15 min.	Good skin reaction.
	23/5/10			,,	..	10 min.	5,525,000	5,560,000	,,	
	2/6/10			Plain water	..	,,	5,760,000	5,850,000	,,	
	14/6/10			,,	104	,,	6,650,000	6,550,000	,,	Poor reaction, patient rather cold.
	16/6/10			..	..	..	5,916,000	6,230,000	,,	
12	18/5/10	F.	Sciatica ..	New Priest	104	10 min.	3,900,000	4,550,000	15 min.	
	25/5/10			,,	,,	,,	3,760,000	4,183,000	,,	
	6/6/10			Plain water	,,	,,	4,383,000	4,683,000	,,	
	10/6/10			..	..	..	4,125,000	4,550,000	,,	

Statistics of Blood Counts—continued.

Case.	Date.	Sex.	Disease.	Bath.	Temperature of Bath, Fahrenheit.	Time of Immersion.	Blood Count immediately before the Bath.	Blood Count after the Bath.	Time from End of Bath to Second Count.	Remarks.
13	23/6/10	F.	Rhoid arthritis	New Priest	104	10 min.	2,933,000	3,091,000	20 min.	
	30/6/10			,,	,,	,,	3,400,000	4,150,000	,,	
	7/7/10			Elec. Priest	102	,,	4,480,000	4,300,000	,,	
	13/7/10			New Priest	104	,,	4,583,000	4,950,000	,,	
14	14/2/10	F.	Rhoid arthritis	New Priest	104	10 min.	4,850,000	5,350,000	15 min.	
15	24/1/11	M.	Convalescent (acute rheumatism)	New Priest	104	10 min.	6,567,000	6,706,000	15 min.	
16	31/1/11	M.	Neurasthenia	New Priest	104	10 min.	4,271,400	4,614,000	20 min.	
17	6/2/11	M.	Neurasthenia	New Priest	104	10 min.	Red, 5,200,000 White, 9,680	Red, 5,970,000 White, 11,250	15 min. ..	
18	3/2/11	M.	Gon. arthritis	New Priest	104	15 min.	White, 13,750	White, 10,937	15 min.	Patient cold after bath, with poor reaction. Had leucocytosis after vaccine; also a meal 1½ hours before.
19	9/2/11	M.	Sciatica ..	New Priest ..	104 ..	15 min. ..	Red, 5,912,500 White, 9,375	Red, 5,818,750 White, 11,875	.. 15 min.	Patient cold; poor reaction.

20	13/2/11	M.	Herpes zoster (healed)	Old Priest	87	30 min.	7,000,000	6,240,000	Immediate	Patient very moderately red in part of body immersed, face and ears blue and cold.
21	30/1/11	M.	Sciatica ..	New Priest	104	15 min.	4,320,000	5,920,000	15 min.	Patient reacted strongly, skin very red and sweating profusely.
22	20/12/10	M.	Rhoid arthritis	New Priest	104	10 min.	6,493,000	6,684,000	15 min.	
23	9/1/11	M.	Locomotor ataxia	New Priest	104	10 min.	5,479,000	5,560,000	20 min.	Poor skin, reaction to bath.

6.—Influence on the Cutaneous Nerve-endings, and reflexly on the Whole Nervous System.—Certain skin-areas have been determined which are correlated reflexly* with internal organs, and stimulation of these areas will reflexly affect the corresponding organs by altering their blood-supply for the time being. Thus a cold douche, or still better a Scotch douche—that is an alternating hot and cold douche—applied to the lower dorsal spine will influence the stomach; over the nates, the pelvic viscera; over Scarpa's triangle, the genito-urinary organs.

To sum up, the effects of immersion in hot mineral water are: (1.) A raising of the body-temperature, with resultant heightened metabolism. (2.) Profound alterations in the blood-pressure and in the relative amount of blood passing through the skin and through internal organs, and in the rapidity of the blood-current. (3.) Certain alterations in the blood-corpuscular count, varying with the kind of water employed. (4.) Increased excretion of toxins by the skin. (5.) Effects on the central nervous system, again varying with the kind of water employed, and its temperature. (6.) As a result of all these processes, alterations in glandular activity and in metabolism generally.

CHAPTER II.

ACCESSORY PHYSICAL TREATMENT.

Massage.—This constitutes one of the most important—perhaps the most important—form of accessory treatment. In the Government spas true massage is given by prescription, and under medical direction only, thus eliminating that element of quackery that appears to be so all-pervading where massage is in question.

The subject of massage is one of great interest, and when the medical profession will give to its physiological action the same serious attention that it would give to a drug of equal potency, it

* We owe much to our knowledge of the nervous correlation of the viscera with certain definite skin-areas to the researches of Head. (Brain: Vols. xvi, xvii, and xix; see also Mackenzie, Med. Chron., Aug., 1892. and Ross: Brain, Jan. 1888.) The posterior spinal roots contain sensory fibres for both the skin and the viscera. If a spinal segment supplies sensory fibres to a viscus and also to a certain skin-area, that area becomes hyperalgesic in disease of the viscus. It also exhibits increased excitability to heat and cold, and the reflexes excited by its stimulation are exaggerated, so that we may reasonably suppose that we have more power by reflex stimulation therapeutically to influence a diseased than a healthy organ. Again, pain originating in the viscus may be referred to the corresponding skin-area, so that, conversely, a soothing of the pain in the skin-area, either by counter-irritants or by such means as warm fomentations for massage, may relieve

will be realized how useful a weapon has been neglected and allowed to be almost monopolized by ignorant and often unscrupulous men. The following brief summary of its physiological action and effects is condensed from the admirable account of Kellogg :—

The effects of massage are *mechanical*, as when the hand of the operator promotes the movements of blood and lymph ; *reflex*, in which distant effects are set up by stimulation of the cerebro-spinal or sympathetic nerve-endings ; and *metabolic*, really a corollary of the other two.

Effects on the Nervous System.—Stimulant or sedative effects may be obtained as desired by varying the forms of manipulation.

Effects on the Muscular System.—Massage greatly increases the blood-supply of a muscle, thereby affecting its nutrition and indirectly affecting the general circulation. Metabolism and heat-production are greatly stimulated.

Effects on the Bones and Joints.—Increased blood-supply to a muscle increases the supply to a bone immediately underlying it, favourably influencing its nutrition, together with that of cartilages, ligaments, and other joint structures. At the same time there is increased circulation through the red marrow, the importance of which to the blood is obvious.

Effects on the Circulation.—The current through veins and lymphatics is hastened, with obvious direct effects on the local metabolism and with secondary effects on the general circulation and the heart's action, and, indeed, on the body generally. Exactly the same effects of hæmatogenesis are seen as after cold baths, a temporary increase of the red-cell count being noted. Phagocytosis is also increased (compare Bier's hyperæmic treatment).

Effects on Respiration.—Depth of respiratory motions* and CO_2 excretion are increased.

Effects on Heat Functions.—Deep massage, by its effect on the muscles, increases heat-production ; superficial massage, by increasing skin hyperæmia, increases heat-loss.

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a deep-seated pain. The explanation of the referred skin-pain may be either an overflow of the irritation from the visceral fibres through the spinal root to the skin-fibres radiating from the same root, or to a confusion of the sense of localization in the higher centres. Thus it is supposed that each peripheral area is represented in the brain ; that the brain receives frequent sensations from the skin-area as against infrequent sensations from the viscus ; and that, consequently, all sensations coming to this particular cerebral centre are apt to be associated rather with the skin than the viscus. (*Cf.* Stewart : Physiology.)

* Increased muscular metabolism, whether as a result of muscular exercise or excited passively by massage, leads to the increased formation of CO_2 in the muscular tissue, and this, reaching the respiratory centre, acts as a " hormone " and excites the centre to greater activity.

Electrical Treatment.—This is very frequently combined with massage to enhance its effect; or it may be given conveniently in the form of a bath, where the patient's body is exposed to the largest possible electrode,* the surrounding water, and the effects of a mineral-water bath are added; or it may be given alone in the usual way with moistened electrodes; or, again, it may be used as a vehicle for the administration of drugs by the skin (ionization).

The subject of electrical treatment has now, of course, grown to such enormous dimensions that it is difficult in a page or two to discuss it at all, even in summary, and I have made no attempt to do more than outline the common and routine measures adopted at the baths. It will be noted that all mention of static electricity is entirely omitted, as in the moisture-laden atmosphere of a bath-house a frictional machine is apt to be unsatisfactory, and the majority of its effects can be obtained by other means.

Both electrical treatment and massage are yet in a primitive state at Hanmer and Te Aroha, but at Rotorua there is a very complete installation of apparatus. The principal forms of electricity used at the bathing establishments are,—

(*a.*) *Direct or galvanic current,* which may be constant or interrupted. Its principal uses are: (1.) To sooth a painful or inflamed nerve, the anode being employed. (2.) To stimulate the regeneration of muscle, especially when the nerve-supply is interfered with, as in wasting consequent on neuritis or anterior poliomyelitis. In this case the stimulating cathode is used. A modification of this is to use either a very slow mechanical interruption of the constant current—a peculiarly powerful stimulant to muscular tissues—or to use the primary coil wound with thick wire. The latter is the method largely employed in electric baths (*vide* Electric Priest baths). (3.) To introduce medicaments through the unbroken skin (ionic medication, cataphoresis).

This method of medication is beginning to attract a good deal of attention, as it enables drugs to be introduced locally in a manner otherwise impossible. Even by hypodermic injection the medicament is rapidly carried away and distributed through the body generally by the blood-current, but, introduced electrically, the free ions enter into combination with every cell within the sphere of influence of the electrode, so that a much larger proportion of the dose reaches its local destination than when given by

* In Schnée's multipolar bath it is usually assumed that the water acts as a large electrode, and that the current enters the patient equally over the whole surface immersed. This, however, is not the case; the great bulk of the current passes through the narrow line of skin which touches the surface of the water—a painful drawback when large currents are employed.

the mouth. It is, of course, perfectly easy to carry out this treatment at home, but it will be found more efficacious if used in conjunction with and as an adjunct to general hydro-therapeutic measures.

The subject of electrolytic dissociation has been already touched on (page 12). In the conditions now under consideration the patient's tissues form the electrolyte, and when a constant current is passed between medicated electrodes the dissociated ions of the drug are physically conveyed through the electrolyte from one electrode to the other, the cations leaving the anode and seeking the cathode, the anions leaving the cathode and seeking the anode. As usually carried out, the process is of course very incomplete, the great bulk of the ions never reaching their destined electrode and remaining entangled in the proximal part of the electrolyte, or, in other words, in intimate association with the molecules of the tissue-cells immediately under the electrode by which they entered.*

The hydrogen ions of acids, the ions of the metals, and the ions of alkaloids are cations, and are therefore introduced from the anode or positive electrode, while the acid radical ions and the hydroxyl ions of alkalies are anions and are introduced from the cathode or negative electrode. Thus, when a solution of sodium-salicylate is used at the cathode, the salicylate ion (anion) penetrates the tissues to seek the anode, while, supposing the "indifferent" electrode (in this case the anode) to be moistened with plain water only, the sodium ions of the patient's tissues (cations) migrate towards the cathode. The current-borne ions can penetrate the unbroken skin, but would appear to take the path of least resistance *via* the hair-follicles and sweat-gland ducts.

In regard to technique, while this is exceedingly simple, yet it requires to be carried out with extreme care, or very serious burns may result. Thus, if the lint pads of the electrode do not evenly and firmly touch the whole area of skin to which it is applied, the bulk of the current will tend to pass through the points of best contact, and very severe electrolytic burns may ensue. These burns are exceedingly slow to heal, and punched-out ulcers with a sloughy base may result, which show week after week no signs of healing. In one such case, which unfortunately occurred in my practice through the imperfect application of the electrode to the

* The depth to which ions penetrate the tissues varies, of course, to a large extent with the strength and duration of the current, but as a general rule it is no more than from 1 mm. to 10 mm. It is probable that the ions of the heavy metals combine with the phosphoric ions of the tissues to form insoluble phosphates, and so pass out of the ionic state in the form of a precipitate in the tissues, and are then unable to penetrate deeper (Lewis Jones: "Latham and English's System of Treatment").

sciatic-nerve area, four such ulcers formed which showed no signs whatever of healing after four weeks' assiduous treatment, but which healed up in a few days under a dressing of allantoin.

The electrodes should be as large as possible, so as to minimize the quantity of current passing per given area of surface. The current should be one of about 2 m.a. or 3 m.a. per square centimetre, and should be turned on and off very gradually. The electrodes should be covered with at least six layers of lint, wet with a 2-per-cent. solution of the drug in distilled water, and well overlapping any metallic edges. In places, such as the knee, where accurate apposition is difficult, a piece of wire gauze, which may be easily moulded to shape the limb, forms an excellent electrode. The current will pass more readily if superfluous grease be first removed from the skin, and care must be taken to protect any excoriations of the skin with collodion, as the current will take the path of least resistance through any broken skin and cause a burn. Sometimes, however, it is desirable to treat ulcerated areas. Thus in a case in which the hands and feet were riddled with obstinate ulcers, arising after residence in a tropical climate and possibly of the nature of framboesia in somewhat unusual form, Schnée's multipolar bath was used, the part treated being immersed in a solution of zinc-sulphate. Owing to the ulceration, only a ½-per-cent. solution and a comparatively weak current could be tolerated, but the results were excellent. I have found also most excellent results in the treatment of pruritus of the vulva and anus.

Perhaps the most frequent application of ionic medication at the Rotorua baths is that of sodium-salicylate in the treatment of sciatica, though the comparative value of the roles played by the salicylic ions and by the simple current itself is sometimes difficult to determine. Another useful application is that of sodium-chloride in the treatment of fibrous adhesions in joints. The cathode is applied to the joint, and the chlorine anions penetrate and soften the fibrous tissues. I have found this a useful adjunct to hydrotherapeutic measures, but cannot help concluding that the unqualified claims made for this method in some quarters are certainly extravagant.

Many other drugs, such as iodine, lithium, cocaine, &c., can be conveniently administered by cataphoresis, and recently attention has been especially drawn to the advantages of this method in the treatment of skin-diseases.* Radium† also may be introduced through the skin by the ionic method, a poultice of radio-active earth being usually employed. So far, however, I am not aware

* Knowsley Sibley: *Clinical Journal*, June 5, 1912.
† Harel: Soc. de Radio. de Med. de Paris, Bull. et mém., May, 1911.

of any sufficiently radio-active earth being available locally. Sir William Ramsay* has suggested that radio-active waters may similarly be utilized in the electric bath by connecting the patient with the negative pole.† The electrons from the dissociation of the niton become positively charged in the discharging process, and are attracted by the patient's negatively charged body.

(*b.*) *Induced Current.*—(1) Faradic, the secondary current from an ordinary sledge coil; (2) sinusoidal,‡ from the electric-light main.

The sinusoidal current is certainly gaining in favour everywhere, as it can be so conveniently obtained by tapping the alternating current electric-light main, and its pulsations are regular and equal; but a good sledge coil has the merit of absolute safety under all circumstances, and by varying the thickness of the coiled wire and its number of turns, and by the use of special mechanical interruptors, a current may be obtained with such fine rapid interruptions as to be practically painless, or may be given with such a slow rhythm as to resemble the interrupted primary current in its effect on muscular contraction.

The principal uses to which this current is put are: (1.) To hasten the regeneration of nerves in such conditions as peripheral neuritis or traumatism, or to maintain their physiological activity in damage to the nerve-centre; a finely interrupted current would generally be used. (2.) To soothe neuralgic pain, as in certain stages of sciatica: here again a "fine" current would be used. (3.) To stimulate muscle *via* nerve, as in anterior polio-myelitis: here coarser interruptions would be employed, and direct galvanic stimulation of the muscle generally combined. (4.) As a general tonic, especially when combined with massage. (5.) As a general tonic in the electric bath, where it would also appear to have a specific effect on acne.

(*c.*) *High Frequency.* — These currents are set up by the extremely rapid oscillatory discharge of a specially arranged high potential apparatus. That in use at Rotorua consists of a 50-cell accumulator, a mercury jet interruptor, a 15 in. Ruhmkorff coil, and the usual resonator and condensation couch. The current is given either with the patient lying on a couch, when he becomes practically a part of the solenoid, or the vacuum electrode is used locally.

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* Address at Bath: B.M.J., Mar. 16, 1912.

† There are, however, considerable mechanical difficulties in this connection.

‡ Alternating current is supplied at Rotorua as three-phase at 6,000 volts. From the substation it is delivered at the baths as single-phase current at 105 volts.

From its somewhat theatrical effects this treatment is specially useful in neurotic cases, and may be looked upon as an excellent form of suggestion. Apart from this, it lowers the tension in cases of high blood-pressure, and would undoubtedly appear to act as a powerful tonic in certain individuals. The local application of the vacuum electrode will often relieve painful conditions such as sciatic neuralgia when all other means fail.

(*d.*) *X-ray.*—This is obtained from the same coil as described for high frequency, and is in constant use, especially for diagnostic purposes. The present apparatus is, unfortunately, somewhat antiquated, as is evidenced by the illustrations of this work.

Medical Gymnastics : Active and Passive Movements.—While theoretically the value of these exercises in the treatment of disease is fully acknowledged, practically their use by the profession is extremely limited. For the most part they require, for their successful performance, either a trained and trustworthy operator or the medical attendant must carry them out himself, an operation demanding much patience and a good deal more time than can generally be afforded. A special institution with its own trained staff can therefore more conveniently deal with these cases than the general practitioner, and there is, in addition, the advantage that douche and bath treatment can also simultaneously be carried out.

Again, the value of exercise in the development of muscle proper is, of course, universally acknowledged, but the value of the accurate dosage of gradually increased resistance is apt to be somewhat overlooked, though this, of course, is the very essence of the familiar Schott movements.

There would appear to be a definite number of muscle fibres allotted to each individual—the " muscular coefficient "—and no amount of exercise or massage is able to add to this number ; but it is possible to cause hypertrophy of each individual fibre, and so increase the size and efficiency of the whole muscle.

Baths, massage, and the like measures flush the muscles with blood, promote the absorption of exudates, and cause a temporary increase of its size ; and electrical stimulation certainly causes some true hypertrophy, as does the voluntary contraction of the muscle by the patient, especially contraction against a progressive resistance.* The superadded muscle, however, is not permanent, as many an athlete has found to his sorrow, and must be kept up by systematic exercise.

The reinforcing effect of an electric current on an exhausted muscle is well known, and electrical stimulation should be used

* Rochard and De Champtassin : Rev. de Chir., Jan. 10, 1909.

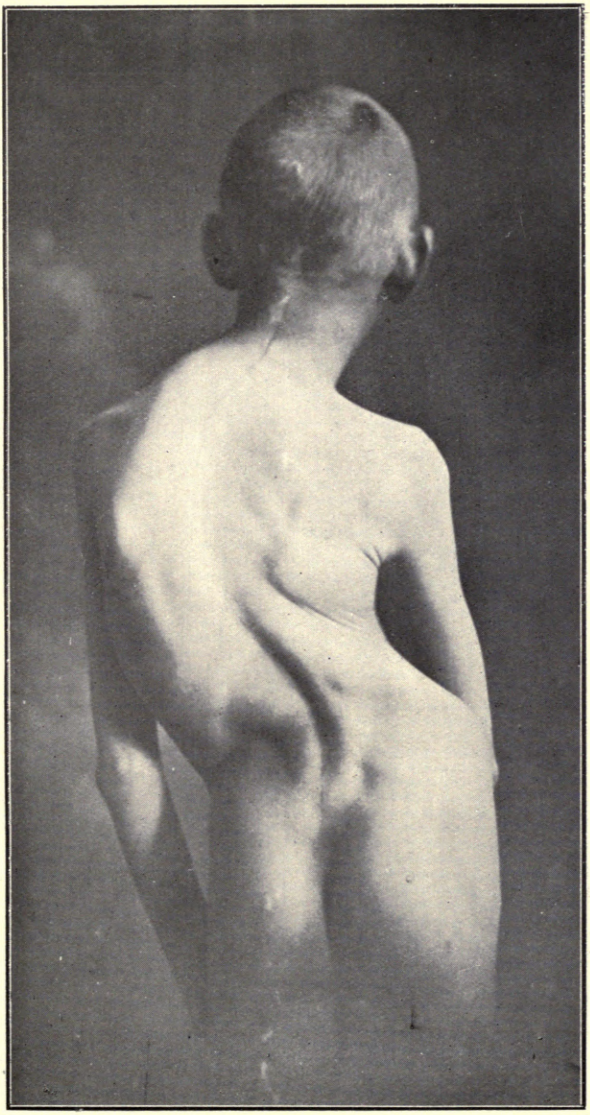


FIG. 1.

At Rest.

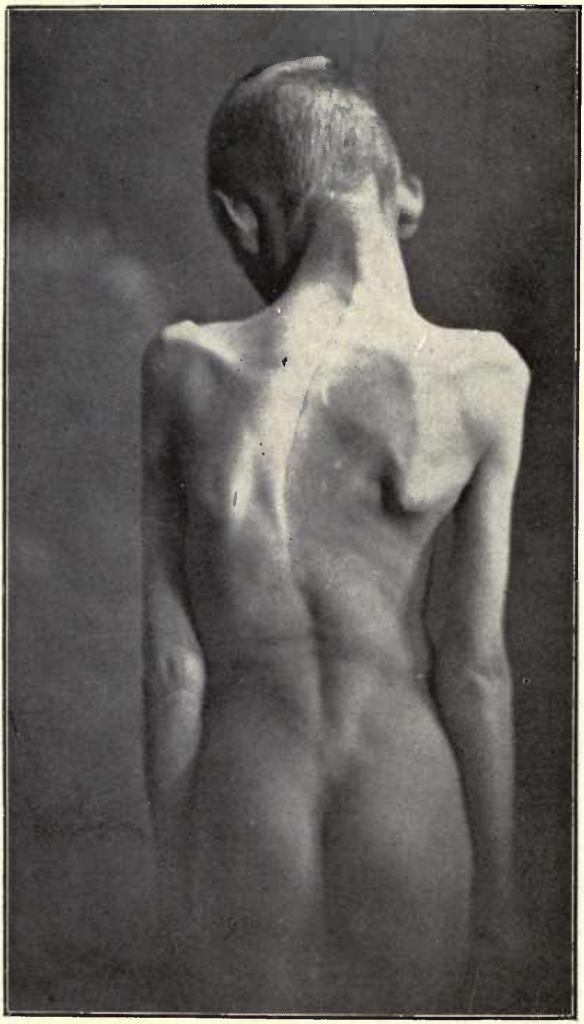


FIG. 2.

Straightened by Voluntary Forced Effort.

FIG. 3.

Left Arm extended.—Curvature increased.

FIG. 4.

Right Arm extended.—Curvature diminished.

FIG. 5.

Hanging from Left Hand.—Curvature increased.

FIG. 6.

Hanging from Right Hand.—Curvature diminished.

in conjunction with exercises. Morton* insists on the value of rhythmic currents of slowly varying strength in atonic conditions of the digestive system, and prefers the slow sinusoidal current to the galvanic interrupted by the metronome, on account of its greater freedom from electrolytic effects. The best results of all, however, are obtained by combining all the above-mentioned agents, for baths and massage determine an increased blood-supply to the part and at the same time hasten the removal of the products of muscular metabolism, thereby enabling the muscle to extract the maximum profit from exercise.

The principal points aimed at in medical exercises are: (1.) The strengthening of selected muscles the action of which will tend to correct deformities as in spinal curvature, or to tone up some hypotonic function as in certain forms of constipation. (2.) The co-ordination of muscular movements, as in locomotor and spastic ataxia. (3.) The breaking-down of adhesions, after traumatism or disease. (4.) Secondary effects, on metabolism in general, and on the circulatory and digestive systems in particular, as a result of educated respiration.

It is not proposed here to consider the subject of medical gymnastics in detail, but merely to illustrate the above points by outlining the methods employed for a few conditions very commonly treated at Rotorua.

(1.) *Strengthening Selected Muscles.*—Cases of *spinal curvature* in adolescents, due to muscular weakness or to the habitual assumption of faulty posture, and before the advent of marked bony changes, can readily be relieved by exercises.

After the ordinary medical examination, posturing of alternate arms will determine which arm must be extended to diminish the curvature (figs. 1 to 6). This, the "key-note position," is used as the basis of a number of exercises, which are carried out daily over a period of weeks or months. At the same time the muscles are strengthened by a course of massage, Scotch douching, and electrical stimulation.

When pronounced bony changes have taken place, only moderate alleviation can, of course, be expected, but even in very advanced cases something can be done. The illustrations afford a case in point. The patient was a boy aged eleven who, apparently as the sequel of acute anterior poliomyelitis at the age of three, got wasting of a somewhat unusual group of muscles, and, as a result, very severe spinal curvature. The vertebræ were rotated, and the ribs crowded on one side and separated on the other, yet in spite of considerable alteration of articular surfaces,

* Morton: Med. Annual, 1909.

after six months' treatment of the kind already sketched, very marked improvement took place. This case, although hardly a suitable one for treatment by exercises, on account of the advanced bony changes, is used for illustration as showing how much may be done by posture in even the worst cases.

Cases of *constipation* due to muscular atony constitute the great bulk of all patients treated by exercises. Consideration will show that abdominal muscular atony enters into at least a very large proportion of all cases of constipation, and with it there is frequently visceroptosis, and probably more or less of the kinking described by Lane.*

Physical treatment aims at regular lifting of the abdominal viscera towards the diaphragm, with strengthening of the muscles of the abdominal wall so as to favour their retention in the normal position, and, as far as possible, stimulation of the muscular coat of the bowel. To these ends flexion exercises of the trunk and lower limbs are carried out, deep abdominal breathing is taught —a species of abdominal auto-massage as well as a muscle-strengthener, abdominal massage and viscera-lifting, stimulation with both faradic and galvanic currents, vibration along the colon, and reflex stimulation by means of the Scotch douche to the lumbar and sacral correlated spinal areas. At the same time, diet is attended to, plenty of water given by the mouth, regularity of going to stool inculcated, and the squatting position advised for defæcation.

(2.) *Co-ordination of Muscular Movements.*—Quite a large number of cases of *locomotor ataxia* are sent or drift of their own accord to Rotorua. Many of these cases are not markedly ingravescent, and there is frequently an apparently total halt in the advance of the central lesion for quite considerable periods. During the quiescent periods a great deal can often be done to minimize the effects of the mischief already wrought. Exercises† of precision of movement and balance are taught, at first simple, and gradually becoming more complex. The essence of the treatment is that each movement shall be slow and deliberate, as accurately performed as possible, and that the patient shall concentrate his whole attention on the movement. At first he is supported by a chair or the attendant, later the movement is performed without support, and finally, if possible, with closed eyes. The results are often surprisingly good.

It would seem as if old nerve-channels were reopened, or as if the concentrated effort forced the nerve impluse through some anastomosing by-path. In this connection it is worthy of note

* B.M.J., April 22, 1911.
† Originally devised by Frankel.

that many ataxic patients receive immense assistance from an ordinary walking-stick held horizontally in front of them by both hands like a tight-rope walker's balancing-pole, a position which can be adopted without attracting attention. The sensation involved in muscular co-ordination in balancing may then enter the spinal cord above the diseased levels.

(3.) *Breaking down Adhesions.*—The forcible breaking down of adhesions by the surgeon under an anæsthetic is, of course, an everyday occurrence, but recurrence of the trouble is not uncommon. Special facilities, however, exists at a spa for the treatment of adhesions. Under the influence of very hot baths and stimulating douches, adhesions previously obstinate may be gradually stretched and broken down by passive movements, and at the same time, with the increased local metabolism induced by the hot water, there is an increased rapidity of repair and a greater likelihood of permanent cure, whether the adhesions have been broken down gradually or quickly and forcibly under an anæsthetic.*

(4.) *Breathing-exercises.*—Apart from the obvious good results on the respiration of filling out badly expanded lungs, there are very important secondary effects, especially from the movements of the diaphragm cultivated in deep "abdominal breathing," on the circulatory system, on the digestive system, and on metabolism generally. The pumping-action of the diaphragmatic movements on the venous trunks, and the auto-massage of the abdominal viscera brought into play, can readily be realized while one watches the movements of a patient well drilled in abdominal breathing.

These exercises are generally combined with others in physical treatment. Thus, thoracic breathing is especially used, in combination with other exercises, in the treatment of spinal curvature, and abdominal breathing in the treatment of visceroptosis and constipation.

There are, of course, a great number of other exercises in occasional employment, but consideration will show that they may generally be classified under one of the above four divisions. Thus the Schott resistance movements would come under (1), "Strengthening Selected Muscles"—in this case the heart-muscle.

Light.—The effects of light on the organism are due to (*a*) the actinic rays and (*b*) the calorific rays. The actinic rays reflexly increase metabolism by stimulating the exposed nerve-endings. Oxidation is increased, as is evidenced by an increasing output of carbonic acid, and the sweat-glands would appear to be stimulated to greater activity.

* See also "Ionization," p. 34.

Light may be used in the form of sun-baths, as the electric-light bath, or locally as in Finsen's method. The latter is not in use in the New Zealand spas, and sunlight is only used indirectly through the routine advice given to cases of chronic auto-intoxication to be out of doors as much as possible.* Both arc-light baths, with predominant actinic rays, and incandescent-light baths, with mixed rays, may be obtained at the bathing establishments.

The effect of the baths is to combine the stimulus of light rays with more or less *radiant*-heat rays as desired, and radiant heat warms the tissues in a manner totally different from the conducted heat of an ordinary bath. The body temperature may rapidly be raised 4° F. or even 5° F., and Kellogg states that there is a markedly increased cutaneous blood count, while there is generally rapid and profuse sweating.

The bath is usually followed by a cooling measure, and the head is kept cooled throughout. It is indicated more especially in chronic purin poisoning and in obesity.

Blue light, in which the ultra-violet rays as well as those of longer wave-length of the visible spectrum are excluded, is said to have a sedative and anæsthetic effect. This treatment can be obtained at Rotorua, but I have not sufficient personal experience of its use to give a positive opinion as to its efficacy.

Heat.—This agent is, of course, a principal factor in ordinary thermal baths and in vapour baths. It can also be used in the form of dry hot air, either locally or generally.

The apparatus in use at Rotorua is heated by dull red-hot electric wires in the walls of a metallic box. By such an apparatus a joint or a whole limb can be surrounded by dry air at a temperature of from 300° to 500° F. The essential effect of this is to cause intense hyperæmia of the part, with all the consequent toxin-neutralizing flood of plasma and phagocytic reparative activity so graphically pictured by Bier.

The resultant relief of pain and stiffness in a joint so treated is very striking, and constitutes the local hot-air bath one of the most useful weapons at our disposal in combating, say, an obstinately stiff and painful knee. The possibility of these baths so raising the local temperature as to exercise a bactericidal action has been already discussed.†

* I have, however, on several occasions seen benefit result from exposing the joints of rheumatoid patients to direct sunlight, and recently have seen a most intractable chronic varicose ulcer heal after prolonged sun-baths, self-administered.

† See p. 19.

The above do not, of course, exhaust the varieties of physical treatment,* but they comprise those at present in principal use at our spas, and, as this professes to be only a guide-book and not a text-book, the other treatments need not be discussed here.

There remains the question how far it is justifiable to use ordinary medicaments in the treatment of mineral-water patients. At the risk of running counter to a great many well-recognized authorities, I would argue that it is not only justifiable, but imperative, to use any or all means of cure that the case demands, be those means drugs or mineral water. When drugs can be dispensed with in the course of balneological treatment, as they generally can, let them be dispensed with ; but every day one is coming across cases that drugs failed to cure, that mineral water failed to cure, but that a combination of the two put right. It would seem pedantic at least to let these cases remain uncured.

It is the same in regard to lotions and ointments. The mineral baths have been credited with the cure of hundreds of cases of eczema and psoriasis, when the real agent has been the bath plus a lotion. The lotion may have been used ineffectually for months beforehand, but acting on a macerated skin, a soothed nervous system, and a "deintoxicated" body, if the word may be coined, it will act most beneficially.

The same applies to the use of vaccines.

There are no more obstinate cases than some inveterate forms of gonorrheal arthritis, whatever the treatment adopted. Baths, largely by raising the body-temperature and so increasing phagocytic activity, may greatly relieve or even cure many cases. Vaccine, too, by conferring "acquired active immunity," is frequently brilliantly successful. On the other hand, failures have been so numerous as to induce some observers to discard vaccine as useless in this condition. If, however, the simultaneous employment be made of physical methods such as baths, douches, massage, &c., which promote the flow to the affected part of the blood with its opsonins, the action of the vaccine is very greatly aided and the results are generally excellent. Indeed, I would advocate a course of balneological treatment almost as a routine measure, with vaccine in these arthritic cases.

* As this work goes to press several new treatments are being installed, notably the Bergonié apparatus for the treatment of obesity and other conditions of faulty metabolism, the Plombières douche for intestinal lavage, and an orthopædic apparatus for dealing mechanically with stiff joints by active and passive movements.

CHAPTER III.

DIET AND REGULATION OF HABITS.

It is in this respect that the New Zealand spas compare most unfavourably with the European. At the chief continental resorts the physician prescribes a course of diet, confident, as a rule, that every facility will be given to the patient to carry it out. More than that, the patient can, if necessary, enter an institution where his diet, his exercise, and his rest are not only prescribed but measured with scientific accuracy. His well cooked and served food can be meted out in calories or in terms of nitrogen, and his excretions quantitatively analysed. We are a long way from that in New Zealand: England still lags behind the Continent, and we lag behind England. The only places where diet can be at all supervised are the Sanatorium at Rotorua and the similar institution at Hanmer, which are practically hospitals for poorer patients. For the rest the matter has to be left to chance, and I have long ago given up, except in hospital practice, all pretence of prescribing a strictly regulated diet, and have confined myself to broad general directions, directions which I know are often exceedingly difficult to carry out.

It is interesting to compare the metamorphosis of a disease like gout under the changed diet of New Zealand as compared with that of the Old Country, especially in regard to the habits of the people in connection with the consumption of stimulants. It is the more important to do so now, as it would appear as if the dietetic habits of the people of Great Britain were gradually approaching nearer to those of Australasia. Broadly speaking, while in the Old Country people take (or took till recently) less meat than New-Zealanders, and alcohol *with* their meals,* in Australasia, where meat has been cheap, enormous quantities of it are consumed, tea is drunk with every meal, and alcohol, when drunk at all, is taken without food—*on an empty stomach.* In England the majority are "moderate drinkers," in New Zealand the majority are to all intents and purposes teetotalers, or, at any rate, only take alcohol at long and uncertain intervals. With them tea as a stimulant† has taken the place of alcohol, and is often taken regularly six times

* It is stated, though I cannot guarantee the accuracy of the statement, that Australians consume 262 lb. of meat a year per head of population, New-Zealanders 212 lb., Americans 185 lb., and British 105 lb. In any case, the British consumption of meat is rising from year to year.

† As is well known, ergographic experiments have proved the stimulant effect of tea on the contraction of fatigued muscle. Compare p. 46, on the stimulant effect of uric acid; also footnote, p. 46.

a day. Again, there is here a woeful deficiency partaken of green-leaf vegetables and fresh fruit, and an altogether disproportionate amount of preserved food in the dietary.

My intimate association with arthritic patients dates back to 1893, when, as Resident Medical Officer of the Mineral-water Hospital at Bath, many hundreds of such cases passed under my observation yearly. The patients were drawn from the labouring class, and chiefly, I think, from the rural population. In gouty cases a history of acute attacks of gout, with the classical symptoms of red-hot great toes and so forth, was generally forthcoming. Tophi were very common and sometimes very large, and the patients, while frequently exhibiting atheromatous vessels, often enjoyed comparatively robust health between the attacks. Tophi were found in both men and women, but were infinitely more common in men. This is a suggestive observation, as, in the class from which the patients were drawn, the men were beer or occasionally cider drinkers; the women more largely took tea.

Here in New Zealand I have seen some ten thousand patients, drawn from all classes, but largely from the labouring class and what would be called in England the lower-middle class, and though the vast majority were arthritic patients, I do not remember seeing fifty cases exhibiting definite tophi, and I have never seen the large tophi I used to see in Bath; of these tophaceous cases, only two were New-Zealand born, and they were not teetotalers.*

Under the changed conditions of life—and diet would appear to be the only condition very greatly changed—gout would seem to manifest itself in a different form. Histories of acute attacks were comparatively rare, and such attacks as occurred were generally barely subacute; there was a tendency to incomplete recovery between the attacks, a condition of chronic joint and fibrous-tissue misery. This condition was more marked among the women than the men, who for the most part did manual labour in the open air and threw off their toxins more easily, and was often associated with chronic dyspepsia, a sallow complexion, a completely edentulous mouth, and a state of mild chronic toxæmia. Indeed, in the present state of our knowledge it would seem almost impossible to draw an exact line of demarcation between the borderland cases of gout and of auto-toxic arthritis caused by mixed infections.†

Faulty teeth are, unfortunately, becoming only too common in every civilized community, but the condition seems to me un-

* Since writing the above I have met two Maori patients exhibiting characteristic tophi.

† I have lately become convinced that many of these cases suffer from chronic oxalic-acid rather than uric-acid poisoning: what is known amongst many Continental physicians as "English gout" of tea origin.

doubtedly worse in New Zealand than in England ; indeed, at any rate in the North Island, it is, in my experience, the exception to find a woman over twenty possessing her own teeth.

Whatever the dietary error, it is evident that an edentulous condition at twenty, continued through several generations, even though the physique of the younger generation so far is good, cannot in the long run conduce to the well-being of the race. Probably neglect of mouth-hygiene has largely contributed to the decay of the teeth, but as this neglect was almost universal in civilized countries in previous centuries, when teeth were better than now, it can be only a minor factor, and the probability of evidence would point to an alteration of diet as a cause.*

DIET IN ARTHRITIC DISEASES.

Diet in Gout.—We may define gout as a chronic intoxication with the products of proteid metabolism, which is accompanied by, but not necessarily caused by, an increase of uric acid in the body, and the symptoms of which may be manifested not only in arthritic attacks, but in protean fashion.

While all are agreed as to the importance of dieting in this disease, yet when it comes to actual details authorities differ so much in their directions, and so many and contradictory diet-sheets have been drawn up—sometimes without any discoverable physiological basis—that at first one is almost tempted to abandon the subject in despair. It is obvious, however, that we cannot afford to neglect, as we have in New Zealand too much neglected in the past, dietetic in conjunction with mineral-water treatment.

The chemistry of proteid metabolism, and especially of uric-acid formation, bristles with such complexities that little apology is needed for a brief summary of the subject before considering the question of diet in gout.

In health the principal end-product of protein katabolism is urea, formed chiefly in the liver, and separated off by the kidneys. A comparatively small amount of uric acid is manufactured in the liver, and similarly separated by the kidneys, but not appreciably formed by them. In gout a somewhat larger proportion of uric acid is formed in the body, though a much smaller amount than the normal is excreted by the kidneys. As urea can be produced by the oxidation of uric acid, it was formerly believed that uric

* It has been asserted that the main cause of caries may be traced to the artificial feeding of infants. While accepting this as *one* main cause, it cannot be the only one, as the natural suckling of infants is at least as common in New Zealand as in England. An interesting point is that the young Maori population, though breast-fed, is beginning to suffer from dental caries as European habits become more adopted.

acid was part of the normal chain of metabolism from protein to urea, and that in gout deficient oxidation prevented the final change. This view is now by no means generally held.

Uric acid may be formed in several ways, and may be endogenous or exogenous. (1.) As in birds, by synthesis in the liver from ammonia and derivatives of lactic acid. Only a small proportion can be so accounted for, the vast bulk being derived from (2) the splitting-up and oxidation of nucleins. Certain glandular substances, such as the thyroid and pancreas, yield abundant nucleo-proteins, which are split up by ferments into protein and nucleic acid. Nucleic acid is further broken down during digestion by a ferment (nuclease) into purin bases, which in turn are converted into uric acid. (3.) Certain proteid food substances, especially animal extracts, such as Liebig's Meat Extract, are already rich in these purin bases. (4.) A smaller amount of uric acid is also formed from the nucleins of the patient's own tissues—endogenous uric acid. (5.) And a certain small amount is formed from the ordinary proteins of both food and the patient's own tissues.

The amount of uric acid formed from food, exogenous uric acid, can of course be controlled by diet; the amount formed from the patient's own tissues, endogenous uric acid, is constant for the individual; and although we cannot modify this latter by diet we can modify its excretion and probably its formation by a course of baths and physical treatment.

The purin bodies with which we are most concerned are: Purin $C_5H_4N_4$, which does not occur as such in the body; the purin bases hypoxanthin and xanthin (oxypurins), adenin, and guanin (amido purins); uric acid; and the methyl purins, caffeine* and theobromine. Nucleic acid, then, is split up by nuclease, and, amongst other things, purin bases, especially adenin and guanin, are liberated. Further ferments (adenase and guanase) transform adenin into hypoxanthin (monoxypurin) and guanin into xanthin (dioxypurin). An oxidizing ferment, or oxydase, converts hypoxanthin into xanthin and xanthin into uric acid (trioxypurin).

As regards the fate of the uric acid, a great part is destroyed in the liver by a uricolytic ferment, and in gout there is probably a deficiency of this ferment either in amount or activity. A cer-

* Theine, the alkaloid of tea, is usually considered to be identical with caffeine, though some physiological experiments on animals would point to subtle differences. The corresponding purin bases in the urine are heteroxanthin derived from caffeine, methylxanthin from theobromine, and paraxanthin from the theophyllin of tea. Thus, tea, coffee, and cocoa raise the total purin excretion, but not that of uric acid. It is possible, however, that the increased excretory work thus thrown on the kidneys may further embarrass their work of uric-acid excretion.

tain proportion of the uric acid, about half the endogenous and a varying proportion of the exogenous, is excreted as such by the kidneys. Under some circumstances, at any rate, uric acid may be excreted by the skin.

We can now consider the relation of these purin bodies to diet. They are found principally in animal foods, where they represent the waste products of the body of the slaughtered animal, and, as such, can have no true food value when ingested by man, though they may act temporarily as stimulants,* and only serve as additions to the waste products of their new host's own metabolism.

Nucleo-proteins are more plentiful in the flesh of young animals such as lamb, or veal, and in glandular substances such as sweetbread, while purin bases occur in concentrated meat-extracts, broths, and stock-soups.

Certain vegetables, especially legumes, also contain purin bodies; so that a *purin-free diet* would not only exclude all meats, but peas, beans, mushrooms, wholemeal, tea, coffee, cocoa, chocolate, and malted liquors. Purin-free substances are carbohydrates, pure fats, and eggs; with milk, white bread, and potatoes almost free. On account of their interference with the oxygenation of nitrogenous foods, some of the purin-free articles are, however, objectionable in themselves if taken in any quantity.

Fortunately, all proteids are not to any important extent concerned in the formation of uric acid, and proteids other than the purins and nucleo-proteids increase the urea secretion only, and not the uric acid.

I take it that for the present purpose we may divide people into three classes: those who, whatever within reasonable limits their purin intake, develop no gouty symptoms; those who develop gout unless their purin intake is strictly limited—the great bulk of gouty patients; and those who, as a result of very faulty nitrogenous metabolism, develop gout from their own tissues or from the irreducible minimum of proteid food, these latter generally the victims of a very pronounced family history.† Faddists would have us diet these three classes—the whole human race—

* In some countries the urine of a virgin is still esteemed as a tonic drink; with us beef-tea has a similarly tonic reputation, and for much the same reason. Modern physiology has largely reinstated beef-tea in the invalid dietary on account of its power of stimulating the flow of gastric juice. Haig ("Uric Acid in the Causation of Disease") maintains that the ingestion of uric acid or purins diminishes the percentage of uric acid which the blood is able to hold in solution, causes its precipitation in organs, and so clears the blood, reduces the condition of collæmia, and acts as a stimulant.

† For many reasons a family history as obtained from the patient himself is vitiated by endless fallacies, yet taking the figures for what they are worth I have found a family history of gout or "chronic rheumatism" (*sic*) in 55 per cent. of my cases.

on the same purin-free food; but, omitting enthusiasts from consideration, there comes the question as to how far we are justified in inflicting such a diet on classes 2 and 3. It would seem that, as in most matters of life, a compromise must be adopted, for the ordinary individual sees little to choose between a martyrdom of gout and a martyrdom of diet. We may aim chiefly at restricting (1) the *quality* of the food, or we may cut down (2) the total *quantity*, or both.

(1.) *The quality.*—The ideal is a purin-free diet; but such a restricted diet is tolerated only by a great sufferer or a faddist: the ordinary man, even when willing to forego ordinary food, is naturally reluctant to make himself a nuisance to his family and his friends. Idiosyncrasy, and especially the digestive power of the individual, must profoundly modify any diet-table drawn up on general chemico-physical grounds.

It is no use prescribing a purin-free food that gives the patient indigestion, nor is it always wise to interdict red meat or even red wine in the case of an anæmic asthenic gouty patient with whom these articles may agree most excellently. It is the quality of the *end product* of the food before it is finally absorbed rather than the quality of the food as it is taken into the mouth that really counts, and this is a matter of the digestive idiosyncrasy of each patient. Nowhere, in fact, is it more true than in matters of diet that "you must treat the patient rather than the disease." My own practice is in a general way to limit the amount of alcohol, tea, salt, and sugar; to enjoin moderation in meat, which may be fowl, beef, or mutton, but, for reasons already stated, not lamb or veal; to forbid twice-cooked meats, soups made from stock, and preserved or salted foods; to increase the amount of green-leaf* vegetables, and, indeed, vegetables generally (except legumes), milk foods, fresh fish,† fruits, and nuts. While, however, there is a general consensus of opinion that in gouty and allied conditions the vegetable elements should predominate,‡ yet the balance of evidence is against a purely vege-

* Luff teaches that the mineral salts of the green vegetables, such as lettuce and spinach, act chemically in preventing the formation of gouty deposits in the tissues, by increasing the solubility of the biurate and retarding the conversion of the quadriurates into biurates ("Influence on Gout of the Mineral Constituents of Various Vegetables," Trans. Roy. Med. Chir. Soc., Vol. 81). Some authorities, however, forbid spinach on account of the amount of contained oxalate.

† Some authorities, however, forbid the use of fish in cases in which there is any suspicion of auto-intoxication as, from the rapidity with which fish decomposes, the ordinary commercial article is already toxin-laden when consumed.

‡ Sir Henry Thompson advised, even in health, one-fourth animal food and three-fourths vegetable.

table diet. W. G. Thompson* writes: "In regard to an exclusive vegetable diet for man the universal experience has been that, while it may keep him in apparent health for some time, it eventually results in a loss of strength and resisting-power against disease."

In regard to fruits there is a hopeless diversity of opinion. Many forbid the use of acid fruits from a confusion of terms, forgetting that the vegetable acids increase the alkalinity of the blood. Certain it is, however, that some fruits—*e.g.*, strawberries—will in some individuals precipitate an attack of gout, and in rare cases the idiosyncrasy is so developed that a single strawberry will bring on an acute attack of erythema. On the other hand, "fruit-cures" are frequently ordered on the Continent of Europe in gouty cases, the grape being the fruit most commonly employed.

Fruits are rich in potassium-salts, and this potassium appears to displace and replace the sodium radicle of salts.† The general tendency of fruits is to alkalise‡ the blood, to render it richer in potassium-salts, to act as a diuretic and as a laxative. In view of the possibility of uric acid being presented to the kidneys as a comparatively insoluble sodium compound,§ this displacing action of potassium may have considerable value, a value enhanced by the simultaneous diuretic and laxative action. Again, by stimulating the salivary glands, fruit tends to counteract oral acidity and consequent dental caries.

It is possible that much-abused tobacco may assist in preserving the teeth in the same manner, and the thought suggests itself that possibly this may be one of the factors explaining the greater incidence of dental caries in women than in men.

There remain certain classes of food-stuffs which, although irreproachable from their purin-content point of view, may yet have a most important bearing on nitrogenous metabolism—viz., fats, carbohydrates, sodium-chloride, condiments, and alcohol. Fats and carbohydrates economize the consumption of proteid; or, in other words, if a larger quantity of hydrocarbons and carbohydrates is ingested a smaller amount of proteid is needed by the body, and what would under other circumstances be a proper amount of proteid food becomes an excessive and, therefore, in gouty cases, a poisonous amount. I think much of the goutiness of this country is due to the excessive consumption not only of tea and meat, but of carbohydrates in a form favouring dyspepsia.

In regard to common salt there is a great diversity of opinion. At recent discussions of the British Balneological Society several

* "Practical Dietetics." See also Major McCay, "Investigations into the Jail Dietaries of the United Provinces," pub. by Govt. of India.

† Bunge; quoted by Stewart, "Manual of Physiology."

‡ *Cf.* Linossier and Taillens: Congress of Physiotherapy, 1911.

§ *Cf.*, p. 47.

speakers condemned the free use of salt in the food of gouty patients, though, somewhat illogically it would seem, the use of saline mineral waters was not interdicted. It has been argued that excess of sodium-chloride tends to promote the formation of insoluble sodium biurate. On the other hand, it is said that "the increased secretion of common salt by the kidneys favours the solubility of uric acid and facilitates its elimination in the urine."* It would seem then that we must maintain an open mind on the question at present, though clinical experience has led me personally to limit the amount of salt and of sodium salts generally.

Similarly, universal clinical experience limits the amount of condiments. This may, however, not necessarily be due to any chemically harmful ingredient of the condiments, but to the fact that they artificially stimulate an appetite when nature cries a halt.

Finally, there comes the very thorny subject of alcohol. There can be no doubt that, as a rule, in gouty subjects the less alcohol that is taken the better, and there is no need to labour the point that beer and sweet wines must be especially avoided; but, owing to the attitude adopted towards alcohol in New Zealand, the question is not one that concerns us here to the same degree that it does in Europe. While drunkenness is not uncommon, the habitual consumption of alcohol is most distinctly unusual, and the great majority of my gouty patients are teetotalers.

(2.) *The Quantity.*—Here, again, the personal equation is a largely determining factor. Plethoric sthenic patients nearly always require some restriction in the total amount of food they take. They should always get up from the table slightly hungry. This would, however, be an unsafe rule in asthenic cases, which, after all, constitute quite a large proportion of the whole.

The quantity of food required in health is still a question unsettled by the physiologist. Until recently Voit's† standard has been generally adopted. His figures rest on the assumption that the average man, guided by his appetite and natural instincts, takes the proper amount of nourishment and no more. Chittenden‡ questioned these premises, which of course rest only

* Weber: Balneotherapy.

† For a man, 70 to 75 kilos weight, doing moderate muscular work—118 grains of proteid (about 18 grammes of nitrogen), 56 grammes of fat, 500 grammes of carbohydrate: total fuel value, 3,000 large calories.

‡ Physiol. Economy in Nutrition. On a daily diet of 36·6 grammes of proteid and total calories of 1,549 he not only maintained his weight (57·5 to 68 kilos) but improved in health and vigour, and rid himself of a "rheumatic" knee. This represented a consumption of only about 0·1 gramme of nitrogen daily per kilo body-weight, or about 0·62 grammes of proteid per kilo (roughly 4·2 grains per pound). McCay's work already noticed is practically a reaction against Chittenden, and I understand that Chittenden's original disciples have already fallen from grace.

on assumption, and experimenting, first on himself and then on a number of other individuals of varying occupation, to find out what was the minimum quantity of food required to maintain nitrogenous equilibrium and to keep the body in perfect health and function, found that a diet of from one-third to one-half that of Voit's was sufficient. He maintained that the minimum intake of proteid necessary to maintain full bodily health was the safest. It is not as if any excess of proteid over this minimum could be stored up as potential energy to be drawn on at need. The excess of proteid undergoes katabolic changes, leucomaines are formed, and autogenous diseases favoured. A lower proteid intake means diminished formation of nitrogenous products of the purin type.

I have quoted Chittenden at some length because, apart from the extreme importance of his conclusions generally, they are of such particular importance in a country like New Zealand, where the proteid ingredient of diet is enormous—far exceeding Voit's standard—and where the regular ingestion of " three good meat meals " a day is looked upon as an essential of civilized and prosperous society.

One other important point remains in considering the total quantity of food required, and that is the degree to which that food is made absorbable by proper mastication. The experiments of Fletcher have proved how much may be done on a very restricted diet when prolonged mastication is employed. Whatever the diet prescribed, it is most important to enjoin prolonged mastication and rest after a meal, for an attack of indigestion is a frequent precursor of an attack of gout. This brings us back to the already mentioned subject of prevalence of faulty teeth, and it is the more important to examine the teeth in all cases, as much arthritic trouble appears to be due to a foul condition of the mouth, and will be benefited by attention to oral cleanliness. This I have noted so frequently that mouth-inspection has become a routine.

Wynn Wirgman and Watson Turner* have drawn attention to the role played by pyorrhea alveolaris in gouty and rheumatic conditions ; and Schichold† to a similar action of septic foci in the tonsils in the ætiology of acute rheumatism. Crofton‡ and Walker Hall§ experimentally produced granular degeneration of the kidneys by the administration of certain xanthin bodies, and Haig‖ has long proclaimed that such widely different diseases

* *Lancet*, Dec. 4, 1909.
† Münch. med. Woch., No. 6, 1910.
‡ Amer. Journ. Med. Sci., Vol. 120, p. 592, 1900.
§ " Purin Bodies," 1903.
‖ " Uric Acid in Causation of Disease."

as epilepsy, uterine fibroma, and diabetes are due to uric-acid poisoning, using the term "uric acid" in a very broad sense to cover all the purin bodies.

Summary.—Gout is due to deficient purin *excretion* rather than to excessive uric-acid formation. In gout of the classical form the deficient excretion of uric-acid is the direct exciting cause of the paroxysms. The deficient excretion may be due to (1) damaged kidneys or to (2) the form in which the uric acid is presented to them :—

(1.) The kidneys may be damaged by the circulation through them of undue quantities of certain xanthin bodies, or by the products arising from the faulty functioning of the bowels, as in the auto-intoxication consequent on proptosed viscera, or they may show the gross changes of interstitial nephritis.

(2.) On the other hand the kidneys may be normal, but there may be a deficiency of some substance in the organism which, when normally present, combines with uric acid and converts it into a readily excretable form ; and it has been suggested that the purins circulate normally in organic combination and abnormally as salts of sodium.

In gout, using the term in the broader sense employed in this book, and including chronic subacute "goutiness" associated with symptoms of auto-intoxication (*cf.* p. 43), uric acid may still be the principal offending factor, but other purins, derived principally from faulty intestinal functioning, may also probably play a large part. A dispassionate review of the data before us would lead us to conclude that both factors are at work, and that both must be controlled if purin-intoxication is to be minimized. In spa treatment properly carried out both factors *are* controlled. By diet we minimize the amount of exogenous purin, and so diminish the amount of work thrown on the faulty kidneys. By baths we increase the toxin excretion of the skin. By baths, douches, massage, and so forth, we heighten the metabolic activity of the body, and hence both the destruction of uric acid in the liver and its excretion by invigorated kidneys. By massage and physical methods we lessen intestinal stasis and thereby auto-intoxication.

By all these methods we adopt an alterative treatment calculated to present to the kidneys uric acid in an excretable form and to lessen endogenous uric-acid formation. And, finally, by giving mineral water by the mouth we flush out the system, and, though this is perhaps more doubtful, exhibit certain salts which may exert a solvent action on the uric acid.

Diet in Rheumatism.—Though acute rheumatism hardly comes within the scope of the balneologist, its relation to subacute

rheumatism is so close that it is convenient to consider the question here. According to the classification adopted in this book (*vide* pages 90, 91) chronic rheumatism is a comparatively rare disease. For many years it has been the universal practice to keep all cases of acute rheumatism on a milk diet and to forbid meat entirely. It is probable that this custom originally arose from the close relationship believed to exist between rheumatism and gout, and it is only quite recently that a revolt has been preached against the tyranny of milk.

Sir James Barr, on the ground that the blood in acute rheumatism contains an excess of lime salts, withholds milk and gives red meat. On more empirical grounds, and in view of the accompanying anæmia of acute rheumatism, I have for several years given a more liberal diet in that disease than is orthodox.

Diet in Rheumatoid Arthritis, using the term in the strict sense defined on page 92, needs an entirely different dietary. Here all our energies must be concentrated on building the patient up. No reasonable article of food that may tempt the anorexic patient can be forbidden, and I have many times seen the greatest benefit result from the addition of the stout-and-milk mixture to the dietary.

The mental confusion of rheumatic and rheumatoid conditions with gout has probably dictated a similar diet in all arthritic cases, a most disastrous result in so far as cases of rheumatoid arthritis are concerned.

It has been suggested that milk may be contra-indicated* in this complaint as in acute rheumatism, but personal experience in a very large number of cases would lead me to affirm its great value as an easily assimilable form of nourishment, and if it should promote the deposition of calcium-salts, that may be looked upon as a step in the process of natural repair.†

In this complaint, more almost than in any other, the condition of the teeth must be attended to.

Diet in Osteo-Arthritis.—The diet here would be largely determined by the antecedent disease—gout, rheumatoid arthritis, or whatever it may have been (see page 92). On theoretical grounds, and considering the tendency to calcium-containing deposits, milk may possibly be harmful.

Diet in Gonorrheal Arthritis.—In view of the profound cachexia frequently present, and the microbic origin of the disease, a generous diet, as in rheumatoid arthritis, is indicated.

* Dr. Florence Theobalds: B.M.J., May 6, 1911.
† *Cf.* Osteo-arthritis, p. 92; see also fig. 10.

Every year's experience has but served to deepen the impression that the great bulk of chronic disease, and a good deal of acute disease, arise directly or indirectly from some faulty functioning of the gastro-intestinal tract, producing an auto-intoxication.‡ This auto-intoxication, by selecting and poisoning very various parts of the organism, is admittedly the cause of very various results of symptom-groups which we label with the name of different diseases. Sometimes the symptoms are the direct result of a toxin on a tissue—*e.g.*, on the nervous system—sometimes the toxin is merely a forerunner that lays the weakened organism open to a specific infection ; and as research deepens, and as results of investigation in different fields are correlated, so the importance of auto-intoxication as a primary factor in disease would seem to increase.

A patient of mine insisted that all disease was due primarily to " wind in the stomach." With a trifling alteration in the phraseology I would almost concur.

Arbuthnot Lane* attributes intestinal stasis and most of the serious abdominal conditions which now so often call for operation to kinks in the gastro-intestinal tract following on visceral prolapse, induced in subjects with feeble musculature of the abdominal wall from the maintenance of the habitual erect position, a position almost peculiar to man. He maintains that, as the stomach and intestines are anchored at certain definite spots, when these organs fall lower kinks inevitably develop at these spots ; that nature endeavours to limit the proptosis by the formation of new ligaments or adhesions, " representing the crystallization of lines of resistance." As a result of these kinks gastric and intestinal stasis necessarily follows, and, with the stasis, an alteration of the quality of the secretions and a multiplication of anærobic organisms. These organisms produce virulent poisons of the aromatic series, which are reabsorbed and are capable of producing grave lesions of vital organs.†

That gout is probably a result of such toxins is a familiar proposition, but that lesions of the nervous system, heart, liver, kidneys, lungs, and mammæ may result, either directly from intestinal auto-intoxication or indirectly from the consequent lowered vitality, is a point not so generally recognized, and is obviously of the most far-reaching importance.

* Arbuthnot Lane : " The Kinks which develop in our Drainage System in Chronic Intestinal Stasis," B.M.J., April 22, 1911.

† Harold Chapple : *Ibid.*, quoting Metchnikoff, " Etudes sur la flore intestinale " (Annales de l'Institut Pasteur, 1910).

‡ Auto-intoxication, using the word in its common loose sense. True auto-intoxication, of course, proceeds from the patient's own tissues, not from his foods, which, though within his digestive tract, are technically *outside* his body.

CHAPTER IV.

Change of Environment includes not only change of scene but of climate, rest from ordinary occupation, amusements, and new interests. The beneficial effects of change, even for the apparently worse, in the convalescence from acute disease, or during the slow course of chronic disease, are so much a part of universal human experience that there is no need to labour the point of proof. It would seem almost an instinct for humanity to sigh for fresh scenes and fresh faces at certain stages of convalescence—surroundings that shall have in them no link of association with the disagreeable time of illness. The patient confined to one room associates a pattern on the wall-paper, a certain blotch on the ceiling, a certain limited view from the window for ever with disagreeable experiences. He is moved to another room, the thread of unpleasant memory is broken, there is a sense of fresh interest, of recuperation.

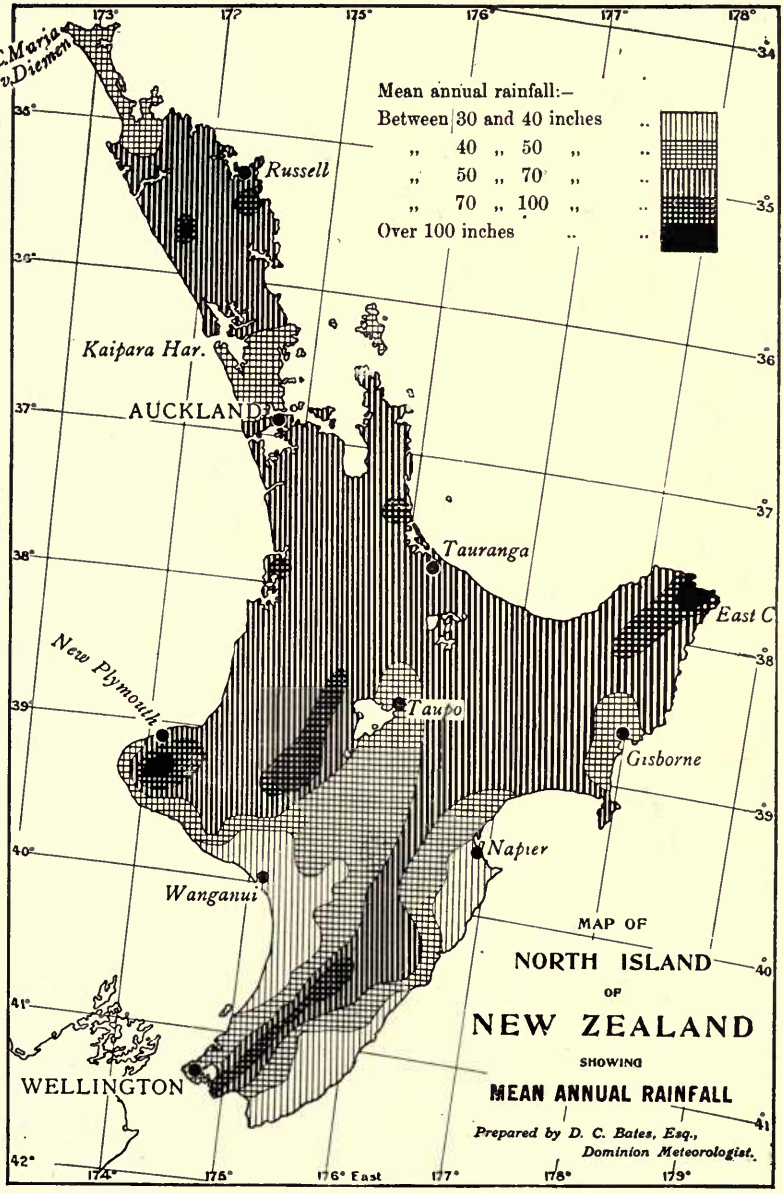
To a less degree this sense of confinement and monotony also applies to towns, and even countries: the same country is only a larger room. A foreign spa, with a foreign tongue and foreign customs, breaks still more links with the past. For this reason, for English patients, the English spas can never hope to cope on quite equal terms with the foreign ones.

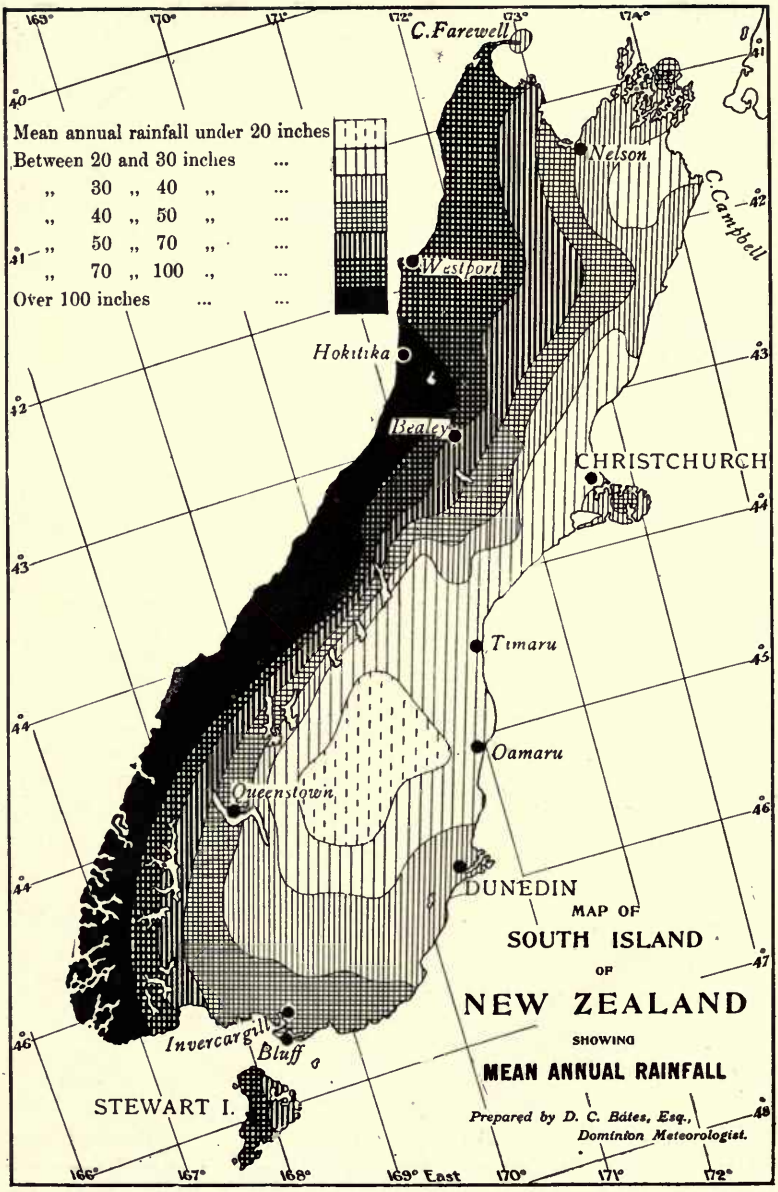
The picturesque Maori inhabitants and the weird thermal phenomena of the Rotorua district are assets of no mean value to a health resort.

Climate.—This may act beneficially in two ways—firstly, and in a general way, as part of the change of environment; and, secondly, in a specific manner, if a resort has been deliberately chosen with a view to a climate specially suited to the individual needs of the patient.

On account of the circumscribed area of the country, the New Zealand spas cannot, of course, compete in the matter of choice of climate with those of Europe, wide-flung over a continent. There is, however, a certain choice of bracing and sedative climates, and for Australian visitors there is the complete change from a continental to an island atmosphere.

The climate of each resort will be considered separately later on, but in regard to the climate of New Zealand as a whole a few generalizations may make the position plainer. Geographically New Zealand bears a very close resemblance to Great Britain, and its climate is largely determined by similar factors. New Zealand


C. Maria v. Diemen
Mean annual rainfall:–
Between 30 and 40 inches
„ 40 „ 50 „
„ 50 „ 70 „
„ 70 „ 100 „
Over 100 inches
Russell
Kaipara Har.
AUCKLAND
Tauranga
East C
New Plymouth
Taupo
Gisborne
Napier
Wanganui
WELLINGTON
MAP OF
NORTH ISLAND
OF
NEW ZEALAND
SHOWING
MEAN ANNUAL RAINFALL
Prepared by D. C. Bates, Esq.,
Dominion Meteorologist.
173°
174°
175°
176°
177°
178°
179°
176° East
34°
35°
36°
37°
38°
39°
40°
41°
42°


Mean annual rainfall under 20 inches
Between 20 and 30 inches ...
„ 30 „ 40 „ ...
„ 40 „ 50 „ ...
„ 50 „ 70 „ ...
„ 70 „ 100 „ ...
Over 100 inches ... ...
C. Farewell
Nelson
C. Campbell
Westport
Hokitika
Bealey
CHRISTCHURCH
Timaru
Oamaru
Queenstown
DUNEDIN
Invercargill
Bluff
STEWART I.
MAP OF
SOUTH ISLAND
OF
NEW ZEALAND
SHOWING
MEAN ANNUAL RAINFALL
Prepared by D. C. Bates, Esq.,
Dominion Meteorologist.
165°
170°
171°
172°
173°
174°
169° East
166°
167°
168°
40°
41°
42°
43°
44°
45°
46°
47°
48°

lies between lat. 35° and 46° S., corresponding in distance from the equator to Spain in the Northern Hemisphere, while Great Britain lies between lat. 50° and 59° N. The difference as regards temperature is, however, by no means commensurate with the difference of latitude. The disturbing element of ocean-currents, and the distance from large land masses, cause the New Zealand climate to resemble much more closely that of Great Britain than of Spain. There is more sunshine and warmer sunshine; less mist and fog; a heavier rainfall, with fewer rainy days; more wind than in Great Britain: but the summer climate is very little warmer even in the North Island. The winter climate, however, except in the inland highlands of the South Island, is very much milder than that of the south of England. In a word, the climate is *more equable* and somewhat warmer.

In the matter of elevation the principal spas are fortunately placed, and allow a good deal of choice. Thus, Te Aroha is near the sea-level, Rotorua about 1,000 ft. above the sea, and Hanmer somewhat higher, and in bracing mountainous country.

Suggestion.—It has been frequently advanced, chiefly by those who have had no opportunity or curiosity to inquire into the subject, that suggestion alone is the curative agent in spa treatment. That suggestion plays a part, and a most important part, not only in the relief of indefinite and borderland cases, but in the treatment of definite disease, it would of course be preposterous to deny, and, indeed, there can be no doubt that the whole atmosphere of a mineral-water resort lends itself most admirably to the fostering of an influence of suggestion. Such a therapeutic agent is one for which we cannot be too devoutly thankful, and one which it would be the height of folly to disdain, and he is most successful who uses every legitimate weapon in his armamentarium as occasion may arise. Doubtless the spa physician finds his environment facilitate the use of suggestive treatment, but there is no medical man who does not consciously or unconsciously use suggestion every day of his life.

CHAPTER V.

RADIO-ACTIVITY AS A FACTOR IN BALNEOLOGY.

There is a growing tendency in certain quarters, which cannot be ignored, to attach a supreme importance to the role of radio-activity in balneology; and, at the risk of appearing to depart somewhat from the attitude defined in the preface, I propose here to discuss at some length the question of radio-activity as it affects mineral-water therapy, and to devote a whole chapter to this very important subject, endeavouring thereby, as far as possible, to reduce to a minimum the number of scattered references throughout the book. The amount of radio-activity in mineral waters is not, of course, very large, and, as a general rule, would seem to vary in inverse ratio to the strength of the water in dissolved salts, so that the "indifferent" thermal waters are generally the most radio-active. In the European mineral waters the amount of radio-activity present varies from 2 Maché units* to 150 Maché units per litre, the latter reading being given by the Gastein water.

In New Zealand a number of the waters have been examined by Dr. Maclaurin,† and, while they all show radio-activity, the amount is comparatively small. The fringe of the subject, however, has hardly yet been touched; the number of springs yet to be examined is stupendous, and it is highly probable that much higher readings will be obtained in future investigations, especially among the cooler springs.

Before, however, considering radio-active waters from a therapeutic point of view, it may serve to make the position clearer if we recall briefly the cardinal physical and chemical facts in regard to radium itself.‡ Radium is one of a series of elements under-

* At the International Congress at Brussels the unit of radiation adopted was the *millicurie*, being the quantity of rays emitted by 1 mg. of metallic radium in one minute. This unit being too large for the convenient measurement of the minute quantities of radio-activity found in mineral water, the Maché unit was adopted (named after Professor Maché, of Vienna), which is the amount of radio-activity which causes a leak of $\frac{1}{1000}$ of an electrostatic unit per second—*i.e.*, 3×10^6 electrons per second—through a standard electroscope.

† Forty-fourth Annual Report, Dominion Laboratory (N.Z.), 1911. See also pp. 86, 87, 88, 109 Compare also Professor Farr's remarks on the radio-activity of New Zealand (non-mineral) spring water; B.M.J., Oct. 14, 1911.

‡ Some apology may appear to be due for restating a certain amount of elementary facts readily available in text books on radium, but, as these latter are not always at hand, a recapitulation makes for general convenience.

going atomic disintegration,* a disintegration which, in so far as its individual atoms are concerned, is of explosive violence†. The first known progenitor of radium is the feebly radio-active element uranium I, its last descendant probably the non-radio-active element lead.

The elements in this long chain of disintegration with which we are most concerned therapeutically are the comparatively long-lived radium and its short-lived immediate descendants, the emanation, and the immediately following "active deposit of rapid change"—radium A, radium B, and radium C.‡

Radium, with an atomic weight of 226, has an average life of about 2,500 years. During that period its atoms disintegrate, each atom expelling one alpha particle—that is, one atom of the element helium—of atomic weight 4,§ and forming one of radium emanation or niton. The latter, which is a true gas, is an element of atomic weight 222, with a definite spectrum and some stability. Chemically, it is one of the most inert substances known, belonging to the series of completely inert gases discovered by Rayleigh and Ramsay. Physically, however, its radio-activity is very much greater than that of radium, and its average life is only 5·6 days.|| It can be converted into a liquid by compression, and can be frozen into a highly luminous ice. Its atom gives off an alpha particle, and is then deposited as the short-lived solids radium A, B, and C, in turn, whose average life is measured in minutes, then passes through the forms of radium D, E, and F (polonium) probably to lead.

* It will be recalled that, in regard to the radio-active substances, or, in other words, the substances undergoing atomic disintegration, the longer the life of the element, if similar rays only are considered, the fewer particles it will be losing at any one moment—that is, the less its radio-active energy at any given moment; and, conversely, the shorter the life of the element the more rapidly it is disintegrating, or the more radio-active it is at any given moment. Put into a formula if E represents the energy of a substance, Q the quantity of the substance, and L the life of the substance, E depends upon $\frac{Q}{L}$. In dealing with emanation, moreover, it must be remembered that on account of its rapid rate of decay the gas cannot accumulate in amount, but is always being freshly formed and disintegrated, and that therefore the amount present at any one time, the fixed amount "in equilibrium," is generally infinitesimally small.

† The total mass is undergoing but a slow change—a minute fraction of its atoms only is undergoing violent and sudden change at any given moment.

‡ J. de Nobele (Arch. d'électr. méd., Jan. 10, 1912) believes radium D to be the active agent in the dissolution of uric acid in gout. There seems to be some doubt as to the nature of the rays emitted by radium D, but probably they are of the alpha or soft beta type (Rutherford).

§ The exact atomic weight is probably a little less than 4.

|| The *total* life, as distinguished from the *average* life, is about one month—that is to say that the activity of any given quantity of emanation, separated from its parent radium, will have diminished to zero in that time.

The alpha particle, or atom of helium, discharged by the disintegrating atom of radium, has, as we have seen, an atomic weight of 4, and carries a charge of positive electricity.* This particle is discharged with a velocity of some 10,000 to 12,000 miles a second, so that its *kinetic* energy is enormous, and accounts in large measure for the stupendous effects of radium.

The stream of alpha particles—the alpha ray—comes from the radium, and, in more vehement fashion, from its offspring the emanation: the beta and gamma rays proceed not from radium, but from its product radium C,† four steps further down the scale of disintegration, so that while it is customary to speak of the beta and gamma rays of radium, such phraseology is not strictly correct.

The beta particle is not an atom of matter, but an electron—an atom of negative electricity divorced from matter, whose mass is one thousandth part of the hydrogen atom, travelling at a speed approximating that of light (185,000 miles per second).‡ It appears to differ from the particle of the cathode rays of a Crooke's tube only in the lower rate of speed of the latter—from 5,000 to 10,000 miles per second. The beta rays, though much weaker than the alpha rays, have considerably more penetrating power, the former penetrating thin sheets of metal, the latter being stopped by a thin sheet of mica. They charge the exposed human skin negatively, and to them is ascribed the special effect on the cutaneous nerves.§

The gamma rays, which appear to be of a type of very penetrating X-rays, are feeble in chemical effect, and would appear to be comparatively unimportant, but owing to their extreme powers of penetration—12 in. of iron or 6 in. of lead,‖—it is possible that their action on the thick tissues of the human body may be more important than would at first appear.

It is not easy to determine the individual parts played by these several rays in the therapeutics of radio-active waters, but it must be remembered that radium-water therapy is really emanation therapy, that emanation acts by its disintegration

* The alpha particle is a definite atom of matter travelling at such an enormous velocity that it actually passes right through other atoms of matter that may stand in its way, ionizing them—that is, charging them with electricity—and incidentally, probably, taking on a positive charge itself.

† Each atom of radium C gives off probably one alpha, two beta, and one gamma particle.

‡ The velocity of beta rays varies, the majority travelling at a velocity of only from 40 to 80 per cent. of that of light.

§ Lazarus.

‖ Soddy. Alpha rays are stopped by $\frac{1}{20}$ mm. of aluminium, beta rays are stopped by 5 mm. of aluminium, gamma rays are only half absorbed by 7 cm. of aluminium (Rutherford).

products, and that the alpha rays constitute by far the greater part of the total energy involved. At the skin surface their action must be incomparably more important than that of the beta or gamma rays, but as the deeper tissues are reached the latter alone can be effective.*

To return now to the subject of radio-active waters. Water in contact with a soluble radium-salt will dissolve both the radium and its emanation; in contact with an insoluble salt, the emanation only; and it is to the emanation that most mineral waters owe practically the whole of their activity. The emanation is removed by the water, and is as constantly renewed in the depths of the spring by the parent radium-salt, to decay in turn in about five days and a half. Thus a condition of equilibrium is established between the formation of fresh emanation and its decay, so that the probabilities are always against a water becoming very highly radio-active, even by long contact with a radio-active source, in direct contrast to what happens in the way of ordinary solution of a salt, where prolonged contact favours a concentrated solution. Again, such a mineral water, radio-active from emanation, will not keep, owing to the rapid decay of the emanation, and cannot be transported to any distance, and rapidly loses, at any rate part of, its quality of "freshness."

It must be borne in mind that radium therapy may be exercised in two absolutely distinct directions.† In one, which concerns the surgeon, the radium-salt itself is used, and huge quantities of rays are concentrated on some diseased tissue, such as inoperable carcinoma, with more or less destructive effects; in the other, which concerns the physician, the *emanation* only is used for its alterative effects on metabolism, and, as Saubermann points out, "radium therapy is emanation therapy . . . . the internal use of radium-salts is killing the goose with the golden eggs."‡

In the former—radium therapy—the results, as in all work bordering on the surgical, are open for all to see; and, while extremely promising in some respects, as yet by no means equal the exaggerated expectations of certain enthusiasts. In the

* Over the distance of penetration of alpha rays, the total energy absorbed in the form of alpha, beta, and gamma rays is about in the ratio of 100,000 : 100 : 1. We should expect the effect of the alpha rays to be confined to within $\frac{1}{10}$ mm. of the surface radiated, the effect of the beta rays may extend to about a centimetre, and the gamma rays through the whole organism (Rutherford, B.M.S., Aug. 17, 1912).

† *Cf.* Engelmann, *Lancet*, May 3, 1913.

‡ Rutherford has pointed out that there is every reason to believe that the emanation itself is quite innocuous, while it would appear to be highly undesirable to introduce unprotected the actual radium-salts into the body, as these may remain permanently in the system and ultimately destroy the tissues surrounding them.

latter—emanation therapy—in chronic diseases of disordered metabolism the results must in the nature of things be less evident and more open to discussion, and are naturally and rightly approached in a spirit of healthy scepticism.

To what extent, if any, the comparatively feeble radio-activity of mineral waters acts as a therapeutic agent is a question of fundamental importance to the balneologist, and I propose to review in some detail such evidence as is so far forthcoming. A certain amount of indirect evidence is afforded by the fact that some of the most successful spas are supplied by springs having very little mineral content, but now known to possess an unusually high degree of radio-activity. This observation by itself would have very little value; indeed, in a former paper,* having noted this peculiar fact, and the question of radio-activity not having at that time arisen, I attributed it to the enforcedly greater care taken by the local authorities to provide the most efficient balneological apparatus, having to meet, as they must, the competition of spas with more richly mineralized waters. Better evidence, however, is forthcoming from experiments on the use of artificially radio-active water, as here the radio-activity can be so very much higher, the dosage so accurately measured, and the disturbing and adjuvant effects of change of environment, suggestion, and spa treatment generally can be absolutely eliminated. The earlier clinical experiments with artificial radio-active water were inconclusive, and indeed some of the water so used was not active at all, the emanation having decayed before use, but the use of water running up to a dosage of 10,000 Maché units gave results which appear to be as definite as any in medicine can be, when we consider the class of disease experimented on.

As to the portals by which emanation from an active water may enter the body, the most important are the lungs, the skin, and the mouth. It may also be given by injection, either subcutaneous, intramuscular, or intravenous; or by douches, vaginal, per rectum; or into cavities, as in dentistry.

1. *The Lungs: Inhalation.*—The emanation is very rapidly absorbed into the blood by way of the lungs, but is discharged with equal facility, passing from the blood into the alveolar air directly the administration of emanation-laden air ceases. According to Lazarus, about 1 per cent. of the inhaled emanation is excreted through the kidneys, and a certain small proportion by the skin and bowels. The usual emanatorium is a closed room containing an apparatus for charging the air with emanation to the extent of 2 Maché units per litre, for absorbing carbonic acid,

* "New Zealand Official Year-book."

and for introducing oxygen. Patients sit shut up in the room for a couple of hours, the gas is absorbed by the alveolar endothelium, and, there being equilibrium of tension between the emanation in the blood* and that in the air of the room, it is not lost by expiration. This equilibrium is maintained as long as the patient remains in the room ; an hour after leaving it his blood is free from emanation. The obvious hygienic disadvantages of this system make the portable inhaler for single patients preferable. Such an apparatus as that of Lazarus and Saubermann or of Engelmann enables the patient, on the principle of the oxygen life-saving apparatus, to respire in a closed circuit containing emanation and oxygen.

It seems fairly certain that radio-active baths owe their virtue largely to the fact that evaporation of the water converts the bathroom into an emanatorium, and with this idea J. de Nobele† recommended that the room should not be too large, that it should be well closed in, and that the water should be agitated.

2. *The Skin.*—De Nobele‡ denied the absorption of emanation through the intact epidermis, but this has now been proved to take place during a bath by Engelmann.§ Also Lazarus‖ found that about 1 per cent. of the emanation taken by the mouth or lungs passed through the skin in the perspiration. Engelmann¶ advises the use of packs after a bath for twenty or thirty minutes till the emanation dries in, in order to secure the longest possible duration of its influence. Schuppenhauer** recommends the use of radio-active fango in the form of packs in arthritic cases, especially of gonorrheal origin. The practical value, if any, of the small amount of emanation absorbed by the skin in a bath remains yet to be determined ; it is certainly too soon to dogmatize.

3. *The Mouth.*—By far the most satisfactory method of administration is that of drinking radio-active water. Not only is the dosage easy to determine and the method of administration simple, but the period of retention in the body is markedly longer than in the case of inhalation. Lazarus, and Saubermann, and Kraus, insist on the importance of a sufficient dosage—1,000 to 10,000 Maché units per diem—and the former points out the importance of a "sipping cure" rather than a drinking cure—that is, the importance of taking sips at frequent intervals, thereby main-

* The coefficient of solubility in blood is 0·2.

† Arch. d'électric. méd., Jan. 10, 1912.

‡ *Ibid.*

§ Engelmann and Strasburger showed the penetration of the skin in 1910. See also Engelmann, Rad. Eman. Ther., *Lancet*, May 3, 1913.

‖ Arch. of the Roentgen Ray, Jan., 1912.

¶ *Lancet*, May 3, 1913.

** Ther. der Gegenwart, Oct., 1903.

taining the charge in the blood, rather than of taking large draughts at longer intervals. His* also pointed out the importance of frequent sipping, but laid great stress on the value of the inhalation method of administration.

We have considered now the general properties of radium emanation in so far as we are concerned as physicians, and have reviewed the usual methods of its administration: it remains to examine its physiological action and the special chemical, physical, and therapeutic action of the several rays on the body.

Physiological Action.—We owe much of our knowledge of the subject to the pioneer enthusiasm of Saubermann,† working in collaboration with Professor Lazarus, Director of the Marien Hospital, Berlin. A summary of their conclusions is as follows:—

1. Their experiments confirmed the statement of Madame Curie—that radium emanation in moderate doses promotes the multiplication and growth of healthy cells and the decay of morbid cells.
2. Emanation increases the output of urine.
3. Emanation increases the activity of the digestive tract, and especially the excretory activity of the bowels.
4. It increases the excretion of uric acid, more especially in individuals whose uric-acid metabolism is faulty.
5. It dilates the blood-vessels.
6. It diminishes the viscosity of the blood, an interesting observation when taken in conjunction with Haig's teaching about the viscosity of the blood in uricacidæmia. As a consequence of these two last actions.
7. It lowers the blood-pressure.
8. It increases metabolism, apparently by acting as a strong ferment in producing oxidative changes, and, setting free certain ferments, exercises a hormone influence on others.
9. It has a pronounced nerve-soothing effect.
10. It increases sexual activity.
11. It modifies the constitution of the blood, causing first hyper-leucocytosis, then leucopenia and increase in the number of red corpuscles.

Fabre and Ostrovsky‡ showed that toxins exposed to radiation or mixed with radium sulphate become much less virulent. The bactericidal effect of emanation in therapeutic doses, except perhaps in the case of the gonococcus, is small: the organisms of

* Progrés méd., Nov. 18, 1911.
† Archives of the Roentgen Ray, Jan., 1912, and Aug., 1913.
‡ Archives d'électricite médicale: Sept. 25, 1910.

cholera, typhoid, and tubercle are unaffected by even strong doses, though the growth of cocci generally is inhibited.

Although not directly bactericidal in small doses, however, it is possible, as pointed out by Pagan Lowe,* that emanation may act indirectly by modifying the culture medium. Thus, in the case of the gonococcus, he quotes the experiments of Wickham and Degrais to prove that a solution of even 1 in 1,000,000 of radium in water will so modify the culture medium as to inhibit the growth of the micro-organism. Bearing in mind the important role which micro-organisms play in the ætiology of some other forms of chronic arthritis, as well as in those chronic intoxications associated with neurasthenia and other conditions of chronic invalidism which constitute a large proportion of the diseases usually calling for balneological treatment, the possible importance of an agent such as radium, which may thus modify the culture medium of the patients tissues, is manifest.†

Chemical Action.—The chemical effects of the alpha rays are much more marked than those of the beta and gamma rays. Thus, alpha rays will cause decomposition of water into hydrogen and oxygen, formation of ozone and nitrogen oxide from air, and definite action on hæmoglobin and on uric acid. Apparently, the beta and gamma rays produce similar but much less pronounced molecular dissociations. Under certain circumstances the disintegration of complex molecules may be replaced by a synthetic action.

Physical Action.—This is at present perhaps rather outside the scope of our therapeutic inquiry, and in any case is too large a subject to discuss in a paragraph. The comparative penetrating powers of the alpha, beta, and gamma rays we have already noted. The alpha rays are much more powerful in their effect in discharging a charged electroscope than either of the other two, and indeed possess the vast bulk of the total radiation energy. All three rays will affect a photographic plate, will cause fluorescence of certain salts, such as zinc sulphide and willemite; and, finally, we know that one gram of pure radium evolves about 133 calories of heat per hour.‡

* Proc. Roy. Soc. of Med. Balneol. Section: May, 1912.

† For further information on the physiological action of radium, see Percival Mills's "Action of Radium on the Healthy Tissue Cell," *Lancet*, 1910, ii, 462; and B.M.J. Nov. 4, 1911; also Victor Horsley and Finzi, "On the Action of Filtered Radium Rays applied Direct to the Brain"; B.M.J., 1911, ii, 898.

‡ It is said that several non-radio-active substances affect the temperature of their surroundings to a slight extent, in either a plus or minus direction. I carried out a long series of experiments with one of these—sulphur—using the fresh crystals deposited round a natural sulphurous-gas vent, but with negative results.

Therapeutic Action.—We have already considered, under the head of "Physiological Action," much of the therapeutic action of radium emanation, and we have seen that emanation appears to act as a stimulant of ferment action in the body. We should therefore naturally expect it to be of value in those diseases of chronic metabolism due to defective ferment action, such as gout, which are commonly treated by mineral water. Gudzent and Lowenthall* state that, after prolonged treatment by radium emanation, the excretion of uric acid in a gouty patient is as prompt and complete as in a healthy individual; also, Gudzent claims to have demonstrated that some forms of radiation prevent the transformation of soluble sodium urate into the insoluble form. His† considers that the insoluble urates are converted into the soluble form, and that the emanation decomposes uric acid into urea and carbonic acid, and he points out that the uric excretion in the urine is increased. Engelmann‡ advises emanation treatment in gout and in various forms of chronic articular rheumatism, in neuritis and neuralgia, in arterio-sclerosis, in asthma, and in chronic pelvic diseases to promote exudates. Armstrong,§ who has had a very large experience of emanation therapy at Buxton in the forms of the radio-oxygen bath, inhalation, and drinking-water activated to a strength of from 2,000 to 10,000 Maché units, claims extremely favourable results from its employment. He lays greatest stress on the drinking (or, rather, sipping) cure, both for its convenience and reliability, and recommends emanation treatment in chronic arthritis, gouty or rheumatic, in several neuroses, in constipation, in high blood pressure, in arterio-sclerosis (except in the latest stage), and in various dermatoses. Saubermann and Lazarus‖ give a very extended list of therapeutic indications, including these already mentioned, nephritis, and diabetes, for which latter large doses are required.

It will be seen, then, that there is a great and growing weight of evidence in favour of the value of emanation therapy, and that there is every possibility that radium emanation may play an important role in mineral-water therapeutics. That it does so play a part I firmly believe, and indeed have so far digressed from the main purport of this book, which is intended as a local guide rather than a treatize on balneology, as to include a chapter on emanation therapeutics. But this is very far from asserting that it is the sole or even the principal agent concerned; and it is only

* *Cf.* Deane Butcher, B.M.J., Oct. 14, 1911.
† W. His, Progrés Med., Nov. 18, 1911 (quoted B.M.J., Feb. 24, 1912).
‡ *Lancet*, May 3, 1913.
§ Armstrong, *Practitioner*, Jan., 1912, and B.M.J., Aug. 17, 1912.
‖ Archives of the Roentgen Ray, Jan., 1912, and Aug., 1913.

fair to conclude with a quotation from the remarks of Professor Rutherford, whose opinion in such a matter is of course entitled to pre-eminent respect and consideration, that "it seemed to him that proof was lacking that the beneficial effect of [mineral] waters was due to radium."

CHAPTER VI.

THE HEALTH RESORTS OF NEW ZEALAND.

IN considering the health resorts of a country it is usual to divide them roughly into two main classes—those whose importance is due to some climatic distinction, and those in which mineral springs constitute the main feature. Though considerable variety exists in the climate of different parts of the country, no organized attempt has yet been made to utilize climatic peculiarities for the purpose of health resorts; and, as the main object of this work is to deal with the spas, the subject of climatic resorts will be dealt with only cursorily here.

Climatic Health Resorts.—Broadly speaking, the climate of the whole North Island is more equable than that of the South, and, with the exception of the West Coast district, the latter is more bracing and subject to greater extremes of heat and cold.

The coast of the North Island, and especially the east coast from Napier northwards, is sedative, or inclined to be relaxing, much resembling the south coast of Cornwall and Devonshire, with very mild winters as an outstanding feature. Such a climate is indicated for young children, in many cases of insomnia, in chronic bronchitis, in old and enfeebled patients with atheroma, and in some heart cases with failing compensation. A caution is needed in these latter cases in regard to exposure to high winds and to hill-climbing, most of the seaside resorts being in very hilly country. Hills can be fairly well avoided at Napier, at Tauranga, and at Takapuna, near Auckland, while Kawau Island, Waiwera (*vide* page 139), and Russell, in the Bay of Islands, are especially mild, though hilly.

Chronic gouty, "bilious," and constipated patients should avoid these coast climates.

Resorts at a Medium Elevation. — Places in the Rotorua and Taupo districts, and more especially in the latter, although only at an elevation of from 1,000 ft. to 1,500 ft. above sea-level, afford

quite definite contrasts of climate to those of the coast. The air is drier and more transcalent, the sun-temperature is still as high, but the shade-temperature much lower, the nights are nearly always cool, and frequently cold and sharp night frosts are common in winter. The whole effect is distinctly bracing.

These characteristics are still more marked in the highlands of Central Otago, where also the effects are less marred than in the North by an undue amount of wind. Such climates are well suited for the majority of invalids, and especially so for arthritic cases, but the practical point of the presence of suitable accommodation must always be considered before sending patients to any spot off the tourist beaten track.

Resorts at High Elevations.—Of these there are none measured by European standards, the nearest approach to one being the Hermitage, at Mount Cook, a Government accommodation-house at an elevation of 2,510 ft. in pure mountain air and surrounded by snow-clad peaks.

As at corresponding altitudes in Great Britain, however, the atmosphere seems to gain its characteristic mountain quality at lower levels than on the great continental masses, and is very distinctly bracing.

Such a climate is indicated in many neurasthenic and cachectic conditions, but should be avoided by patients with marked atheromatous changes or failing hearts, on account of the additional strain thrown on the cardio-vascular system. It should be added, however, that at present Mount Cook is rather a tourist than a health resort.

THE MINERAL-WATER HEALTH RESORTS (SPAS).

Rotorua.

While New Zealand is a country peculiarly rich in mineral springs, there are only three or four places that have yet reached such a state of development as would entitle them to be dignified with the name of spas. Of these, Rotorua, Te Aroha, and Hanmer are managed by the Government, and Rotorua alone can be considered fully equipped in accordance with European standards.

Rotorua, a town of some 3,500 inhabitants, is the largest place in the thermal district, and takes its name from the lake on whose shores it is built. It is some thirty miles from the nearest coast, is easily reached by rail from Auckland and Wellington, and was selected for special development on account of the unique combination that it offers of absolutely distinctive and unlike thermal waters.

Indeed, there is probably no spa in the world so rich in mineral waters covering so wide a range of therapeutic possibilities. On the one hand there are the alkaline siliceous waters arising in immense quantities from a huge number of springs at or near the boiling-point, each differing in minor details of analysis from its neighbour ; on the other, there are sulphuric-acid hot springs, more circumscribed in area and output, but quite unlike any waters known in Europe, and possessing unique powers of stimulating the cutaneous circulation when used as a bath. Then there are the hot " mud springs," consisting chiefly of silicates with a large proportion of free sulphur, which are used for " fango " baths ; the steam vents mixed with sulphuretted hydrogen, and those charged with sulphurous acid, both of which are used for vapour baths ; and there are springs bubbling with free carbonic acid.

Climate.—The climate of Rotorua is determined first by general geographical considerations, latitude, the surrounding ocean, and prevailing winds, which affect the climate of the country as a whole ; then by local conditions, which have perhaps an even more potent influence.

Situated in latitude 38° 8′ S., an equivalent in Europe to that of the south of Spain, there would naturally be a very hot climate were there not important modifying local features. We have already noted the equable nature of the climate of New Zealand as a whole, due to the immense area of surrounding ocean ; the local factors remain to be dealt with.

The town is situated on the shores of a large lake, at an altitude of nearly 1,000 ft. in a great basin of the hills some twenty-five miles long by ten broad. These hills rise to a height of 1,000 ft. or 1,500 ft. above the level of the valley, and serve to shelter it to some extent from the full force of the winds, but they are lowest to the south-west, the direction of the prevailing wind.

The south-west is a cool and bracing wind, coming from the high central plateau of the North Island and snow-clad mountains, and brings fine weather, sunshine alternating with clouds. It profoundly modifies the climate, and the weather is never sultry or oppressive while it is blowing. Frequently, however, it is somewhat boisterous and uncomfortably cold, and this constitutes what is perhaps the most serious climatic drawback to Rotorua.

The north-east to north wind, which comes next in importance, is the rainy wind. When it blows Rotorua experiences its nearest approach to mugginess, and rain almost invariably follows. In fact, at these times the characteristic inland climate is exchanged for a moist sea climate, the sea to the north-east being only thirty miles away.

In very fine settled weather, however, there may be a daily alternation of light airs from the north-east and south-west, a true sea and land breeze, when the north-east wind no longer brings rain.

The west wind is also rain-bearing, but less so than the north-east.

The altitude, however, is perhaps the most important local factor in modifying the climate. While not sufficiently high to serve as a contra-indication in atheromatous and other cases in which a high altitude is undesirable, it is quite sufficiently raised to render the climate distinctly bracing except at certain seasons. The slightly rarified air is more easily penetrated by the rays of heat and light, while radiation of heat and evaporation of moisture proceed more rapidly. As a consequence, there is a greater brilliancy of atmosphere than at places near the sea-level, the rays of the sun are hotter, the temperature in the shade much cooler.

Another effect of the altitude of Rotorua is the comparative dryness of the atmosphere. This, while it is undoubtedly diminished by the presence of the lake and by the large amount of steam constantly arising from the hot springs, is sufficiently marked, as a rule, to prevent the air from feeling relaxing, except when the north-east wind is blowing. Probably, however, the nature of the soil, the sparseness of the vegetation, and the configuration of the surrounding hills have all something to do with the local freedom from mists. It is quite common to see the whole circle of forest-clad hills full of tangled mists while the broad valley beneath is perfectly clear.

Sunshine.—As in New Zealand generally, there is a very considerable amount of bright hot sunshine, a matter not only of physical but psychical importance to the invalid (*cf.* table, page 70.)

Rainfall.—This is fairly heavy, but fortunately tends to come in short sharp rain-squalls, when a large amount may be registered in a few minutes, or is massed into two or three days of heavy downpour, ushered in by a north-east wind.

The Season.—In so far as the treatment of invalids is concerned the season lasts all the year round, but the busiest time is from Christmas to the end of April. February is sometimes uncomfortably hot and close, and should be avoided by those needing a bracing climate, while the late winter and early spring, July to September, are apt to be wet. Frequently, however, the winter is remarkably fine and suitable for those invalids who need a tonic climate. In a good winter there may be a very large proportion of fine days, with a blue sky, a really hot sun, a minimum of wind, a cold shade temperature, and a fairly keen frost at night.

If only the houses were built more warmly, a course of winter treatment would hold out many advantages over the usual summer one.

Sanitation, &c. — The water-supply is beyond reproach. A spring issuing from the foot of a hill discharges practically direct into the mains, and the water is not only clear and sparkling, but is free from any possible risk of contamination.

There is an efficient water-carriage sewerage system discharging into a septic tank, well removed from all habitations.

The average death-rate for the three years 1909, 1910, 1911 was 10·8 per thousand.

Accommodation.—There are four hotels and more than thirty boardinghouses, affording altogether accommodation for about fifteen hundred guests. For patients of the hospital class there is the Government Sanatorium of thirty-five beds, devoted to balneological treatment on modern lines.

Amusements.—While not, of course, coming up to the European standard in the way of casinos, theatres, and bands, amusements have been by no means altogether neglected in Rotorua, while for outdoor attractions, in addition to beautiful lake trips, playing-greens, lawns, and public gardens, the interesting thermal phenomena—geysers and so forth—and the picturesque Maori villages, lend an element of piquant charm which few spas can rival.

The Baths.—There are several distinct establishments—the New Baths, the Pavilion Baths, the Postmaster Baths, the Duchess Bath, the Blue Bath, and the Spout Baths.

The New Bath.—This is a fine establishment, run on the familiar European lines, with a large number of comfortably fitted private bath-rooms, public baths, massage-douche baths, vapour baths, cooling-rooms, a well-equipped massage and electrical department, and consulting-room and waiting-rooms, the whole run under the strictest medical supervision. In the great central hall is the "pump-room" and concert hall, and in the basement the mud baths.

The Pavilion Baths house in somewhat primitive fashion, the old Priest baths (*vide infra*), public and private Rachel baths, and the ladies' hot swimming-bath.

The Duchess Bath is a hot swimming-bath under cover, and the *Blue Bath* another hot swimming-bath, open to the sky, for men only. Here, too, are the *Sulphur Vapour Baths.*

The Spout Baths are at Whakarewarewa, and consist of a series of waterfalls of hot water, which form primitive but exceedingly pleasant and efficacious douches.

The Postmaster Baths, described below, are on the lake shore some half a mile away from the main buildings.

*Meteorological Statistics.**

At	—	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
Mean Temperature of the Air in Shade for Two Years to December, 1910.														
Auckland ..	Mean max. ..	72·5	75·3	72·7	66·1	63·0	59·5	57·9	58·5	60·5	63·6	67·8	71·4	65·7
	Mean min. ..	60·3	62·7	60·7	53·8	53·2	50·8	48·0	47·2	49·4	51·4	55·4	58·2	54·3
	Mean temp. ..	66·4	69·0	66·7	59·9	58·1	55·2	53·0	52·9	54·9	57·5	61·6	64·8	60·0
Rotorua ..	Mean max. ..	75·3	78·0	72·7	65·1	60·5	56·6	55·6	56·6	60·1	64·7	70·5	72·8	65·7
	Mean min. ..	54·6	54·9	54·3	44·5	43·8	44·6	43·1	42·9	41·2	45·7	49·8	51·5	47·6
	Mean temp. ..	65·0	66·4	63·5	54·8	52·1	50·6	49·4	49·7	50·6	55·2	60·1	62·2	56·6
Te Aroha ..	Mean max. ..	78·2	80·3	75·6	68·5	63·4	60·9	59·2	59·7	62·8	67·3	72·3	76·4	68·7
	Mean min. ..	53·9	58·8	50·7	46·5	45·9	47·7	42·8	43·2	44·4	48·7	57·2	58·5	49·9
	Mean temp. ..	66·1	69·5	63·2	57·5	54·6	54·3	51·0	51·5	53·6	58·0	64·7	67·5	59·3
Hanmer ..	Mean max. ..	70·1	73·7	68·5	63·0	58·6	54·3	47·1	53·6	58·2	62·5	67·9	71·2	62·4
	Mean min. ..	49·4	50·8	48·8	40·9	39·7	35·8	32·7	36·3	37·3	43·6	45·9	49·5	42·5
	Mean temp. ..	59·7	62·2	58·6	51·9	49·2	45·1	39·9	44·9	47·7	53·0	56·9	60·4	52·4
Total Rainfall in Inches, 1909–1910.														Total.
Rotorua ..	1909 ..	3·46	0·06	6·65	2·88	5·47	3·62	8·96	12·86	4·21	3·96	3·45	3·77	59·35
	1910 ..	8·94	5·60	5·92	1·11	4·22	4·50	6·11	4·52	1·62	3·27	2·14	3·18	51·13
Hanmer ..	1909 ..	7·48	1·18	3·49	1·33	3·04	1·29	2·94	3·79	1·78	4·82	2·81	5·23	39·18
	1910 ..	5·92	1·15	4·41	3·68	3·12	4·74	5·32	3·54	2·49	1·11	2·22	5·36	43·06
Sunshine Records, 1911 (Average Hours per Diem of Bright Sunshine).		H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
Rotorua† ..	..	9 4	7 55	5 58	4 44	3 40	4 10	4 32	6 3	6 22	7 46	7 49	7 42	6 18
Hanmer‡ ..	..	8 11	7 10	7 0	4 20	5 44	3 32	4 16	5 37	5 56	7 46	6 46	7 1	6 6

* Kindly supplied by the Rev. D. C. Bates, Dominion Meteorologist. † Total hours: 2,303 h. 33 m. ‡ Total hours, 2,231.

The Mineral Waters.

The Alkaline Sulphur Waters. — We have seen that the acid waters are without parallel in Europe, and possess certain unique advantages for external use. The alkaline waters represent a type common to many of the most famous spas of Europe, and are suitable both for bathing and drinking purposes. They contain a moderate amount of common salt in solution, but differ from the majority of European waters in being highly siliceous,* and, indeed, the silicates constitute so important a constituent of the waters, both from the chemical and therapeutic standpoint, that they might be classified as siliceous instead of sulphur waters with at least equal propriety. They contain both carbonic acid and sulphuretted hydrogen gases in solution, and are characterized by their very high temperature (180° to 212° F.), perfect clearness, and soft, emollient feel.

Seen in bulk in a perfectly fresh condition they present every gradation of tone, from almost colourless to a clear and beautiful blue, the colour being due to ferrous silicate and carbonate. Under certain conditions—*e.g.*, storage and free exposure to the atmosphere —the waters become opalescent, and finally a blackish deposit of oxide and sulphide of iron and silica is deposited. The principal ingredients are chlorides, sulphides, and silicates of sodium, together with sulphuretted hydrogen and carbonic acid as free gases.

Although they arise from hundreds of scattered springs, these waters, with minor variations, conform to one great type both chemically and physically. They would appear to be all derived from a common source, probably at considerable depths, and to be modified in transit to their various surface vents.

In all cases the waters reach the surface at a temperature approaching the boiling-point, and where there would appear to be exceptions to this rule it will always be found that the lowered temperature is due to stagnation caused by a comparatively small supply flowing into a large effluent pipe or pool. Such waters, heated far above 212° F. under a pressure of several atmospheres, burst into steam with explosive violence if they happen to reach the surface rapidly enough, and under certain conditions exhibit geyser-action.†

The most famous of these springs, although by no means the largest, is the Rachel, which constitutes the main supply of alkaline water to the baths.

* As to the origin of the silicates, water at a great depth may reach a temperature that will easily dissolve the most refractory silicates. Glass is soluble in water at 410° F.

† For a full account of the Rotorua geysers the reader is referred to the chapter on Rotorua in my pamphlet "The Mineral Waters and Health Resorts of New Zealand," published by the New Zealand Government.

The Rachel Water. — The surface temperature of the spring varies from 185° to 200° F., according to the rapidity with which the water is being drawn off. Occasionally it boils energetically. The water—which has a soft silky feel, due to the alkaline silicates, and a somewhat nauseous taste, due to sodium-sulphide, is led in iron pipes—which, by the way, tend to be rapidly occluded by silication—to the baths, where it is used for both bathing and drinking purposes.

Analysis of Rachel Water (1912).

	Grains per Gallon.
Sodium-chloride	65·87
Sodium-sulphide	10·27
Sodium-silicate	23·78
Sodium-bicarbonate	13·47
Sodium-sulphate	1·50
Sodium-borate	1·85
Potassium-chloride	1·26
Lithium-chloride	0·42
Calcium-chloride	trace
Calcium-bicarbonate	0·41
Ferrous bicarbonate	0·01
Carbon-dioxide	9·17
	128·01

Temperature, 194° to 200° F.

Internal Use.—The most important therapeutic ingredients of this water are sodium-silicate, the sulphides, and the iron salts. So little is known of the action of silicates that for a long time I felt some hesitation in using so highly siliceous a water as the Rachel internally, not realizing the important part played by silicon as a constituent of the body.* For some years now, however, I have made ever-increasing use of it, and, while never able to discover any ill effects that could reasonably be attributed to the silicates, have accumulated considerable clinical evidence as to their beneficial action.

Felix† was one of the first observers to point out the antiseptic properties of the alkaline silicates. He also showed‡ the power

* As silicic acid is an integral constituent of connective tissue, the total amount required by the organism is very considerable, the proportion being greater in young children than adults, thus: Muscle contains 24 milligrammes per kilo of dried tissue; skin 45 milligrammes; tendon, 64 milligrammes; dura mater, 87 milligrammes; fascia, 106 milligrammes. See also the experiments of the New Zealand Agricultural Department in feeding lambs on sodium silicate.

† *Gazette des Eaux*, May 19, 1898 (quoted by Weber).

‡ "Annales d'Hydrologie," March, 1898.

of a mineral water containing such silicates (Sail les Bains, 9·1 grains per gallon) to dissolve uric acid in a test-tube. Such an experiment is, of course, very inconclusive, as the conditions in which the silicates exist in the blood after absorption may be wholly different. That they are so absorbed is shown by the experiments of Zikgraf,* who gave 1 gramme per diem of sodium-silicate by the mouth, and found the drug excreted in the urine. In a later communication† he draws attention to the beneficial results in pulmonary tuberculosis of drinking the mineral waters of Glashagen, which contains 4 milligrammes of meta-silicate of sodium in 100 grammes of water.‡ Pascault§ gave teaspoonful doses of a solution of sodium-silicate of a strength of 172 grammes per litre as a gastric sedative and anti-fermentative in gastric flatulence and pain, and in cases of intestinal auto-intoxication. Sodium-silicate has a remarkable power of arresting the fermentation of organic matter, and the beneficial effect of Rachel water in many cases of dyspepsia and auto-intoxication, and consequent goutiness, is probably due to the silicate.

The same agent is also probably in part responsible for the rapid healing of many varicose and other ulcers in patients taking the baths.‖ Scheffer¶ gave sodium-silicate in arteriosclerosis, using an aqueous solution of 1 in 18, and a dose of two or three tablespoonfuls daily in milk, water, or wine; and recently a specific action has been claimed for the drug in the treatment of adenoma.**

Toxic Effects.—While there is no evidence of the mechanical deposition of silica in the body in the same manner in which it is so freely deposited in pipes conveying mineral water,†† experiment

* Beitr. z. Klin. de Tuberkul., 1906, bd. 5, H–ft. 4.

† Centr. f. im. Med., May 16, 1908 (quoted Med. Annual, 1909).

‡ He found a diminution of the leucocyte count in the peripheral blood, with an increase of multinuclears, which, according to Arneth's theory, means that the blood is more resistant and better able to deal with infectious agents. It is suggested, in explanation of the more rapid healing of tuberculous cavities under the administration of silicates, that as silicates constitute an important element in connective tissue they promote the nourishment of that tissue in the lungs. If this is so they would be contra-indicated in chronic arthritis with a tendency to adhesions.

§ Bull. Gén. de Thér., July 30, 1907.

‖ Compare Felix, *Gazette des Eaux*, May 19, 1898. Also the Rachel water is extensively used in the Rotorua Hospital as a local bath in septic wounds, with most excellent results. Compare the silicate treatment of cancer by Zeller (Muench. Med. Woch., Aug. 20, 1912; and by Czerny, *ibid.*)

¶ Med. Press, Sept. 30, 1908.

** Percy Wilde: Med. Annual, 1912.

†† As a matter of fact, silicates absorbed into the blood tend to have a decalcifying effect on the body generally. In this connection compare the advice of Sir James Barr, who in rheumatism gives oatmeal porridge for the decalcifying effects of its contained silicates.

has shown* that large doses of silicon, administered over a considerable period, cause uniform symptoms of poisoning of the nervous system, such as headache, dizziness, and tremor. Rashes appear on the skin, and symptoms of intestinal irritation are set up.

Sulphides.—Authorities differ as to the therapeutic value† of the various sulphides. Some, while admitting the utility of sodium-sulphide, deny any virtue to hydrogen sulphide; others affirm the potency of hydrogen sulphide apart from other compounds; and Kisch‡ pointed out that sulphuretted hydrogen affords a combination that permits the introduction into the body of sulphur in the finest conceivable division. The matter is still *sub judice*. An older analysis showed the sulphide entirely as sulphuretted hydrogen, but an analysis made this year of water carefully collected and examined as soon as possible after collection returns the sulphide as a sodium-salt. This salt decomposes very rapidly on exposure of the mineral water to the atmosphere, a double set of changes taking place: on the one hand the sodium combines with carbonic acid to form sodium-carbonate, part of the sulphur being set free as a flocculent precipitate and part combining in a nascent state with the hydrogen of H_2O to form H_2S; on the other the sulphide undergoes conversion successively into hypo-sulphite, sulphite, and sulphate of sodium.§ Hence the apparent discrepancy between the analyses. In the presence of alkaline salts, sulphur is thought capable of acting as an oxygen-carrier, thereby increasing the intra-molecular oxidation of albumin.

It is believed, too, that sulphur waters taken internally stimulate the secretion of bile, and indirectly, especially in plethoric individuals, the katabolism of red blood-corpuscles, an action by no means always desirable.

At Aachen, where the sulphur water, in conjunction with mercury, is used so extensively in the treatment of syphilis, it is believed that it brings out symptoms of latent and, to that extent, dangerous syphilis. Mercury is supposed to be stored up in the tissues as an albuminate, the sulphur hastens albuminous katabolism, and thereby the excretion of mercury, and the latent symptoms become evident.

Sulphur waters are supposed to have a specific action in chronic lead-poisoning, but I am not aware of any direct evidence that the sulphur as such, and not the increased metabolism set up by spa treatment, is the real agent. A similar specific action is claimed for the non-sulphurous thermal waters of Bath.

* Schulz: Deut. Med. Woch., No. 38, 1903.

† For an account of the toxic effect of sulphides see article in B.M.J., July, 1912, on the researches of Kojernikoff.

‡ "System of Physiologic Therapeutics" (Cohen), London, 1902.

§ Com are Weber, "Climatotherapy and Balneotherapy," London, 1907.

Recently Dr. Brown*, of Harrogate, has published some very interesting results of his inquiries into the physiological action of sulphur waters, using as the basis of his experiments the "strong sulphur water" of Harrogate. This water contains about 14 grains per gallon of sodium-sulphide, but as it also contains 840 grains of sodium-chloride, as well as smaller quantities of the chlorides of calcium, magnesium, and strontium, it is by no means certain that all his results can be attributed to the action of the sulphide. The dose of sulphur water was generally one pint (20 oz.) taken on an empty stomach in the morning. Space forbids more than the very briefest summary of his results, but, in view of the scantiness of our previous accurate knowledge of the pharmacological effect of the sulphur waters generally, these results are of very great value. They may be stated as follows: Sulphur water taken by the mouth increases oxidation and general metabolism. The increase of metabolism is shown by—(1) The greater total nitrogenous output in the urine, up to 10 per cent. increase; (2) 10 per cent. increase in the excretion of phosphates; (3) increase in the total urinary solids; (4) increase in the excretion of endogenous kreatinin, 13 per cent.; (5) increase in the excretion of endogenous uric acid, up to 18 per cent.†; (6) the oxidation of purin bodies to uric acid is increased. Thus, hypoxanthin administered by the mouth during the exhibition of sulphur water is recoverable as uric acid in the urine to a percentage almost double that of the normal and in two-thirds of the normal time.

Iron Salts.—These exist in the fresh state as bicarbonate, and their therapeutic action in such minute doses is perhaps doubtful. Probably the presence of an easily decomposed iron-salt would tend to minimize the katabolic effects of sulphides on hæmoglobin in the intestinal capillaries. For the same reason, of interaction between the iron salts and the sulphides, the beneficial results in anæmia would be minimized.

Lithium Chloride (see remarks on pages 101 and 105).

Sodium Borate.—The recent discovery of this salt in Rachel water is very interesting, and may account for its occasional purgative effects. (Compare page 100.)

Electrical Conductivity—As this may be taken as a measure of the number of free ions in a mineral water its measurement is a matter of some interest. In the following tables‡ a column

* Proc. Roy. Soc., Med. Balneol. Sec., May, 1911.

† It is only fair to note that some Continental authorities utterly condemn the use of sulphides in gout.

‡ These measurements were kindly made for me by Mr. Hawley, of our electrical staff.

of water $\frac{3}{16}$ in. in diameter was used at a temperature of 68° F. Water from the town main was used for purposes of comparison, and a 50-volt current passed between platinum electrodes. The waters were tested when freshly collected, and again after storage.

Water.	Distance between Electrodes.	Fresh (Current in M.A.).	Tested after Stagnation for Four Weeks (Current in M.A.).
Town main	$\frac{1}{2}$ in.	1·5	1
Rachel water	$\frac{1}{2}$ in.	17·0	15
Priest water	$\frac{1}{2}$ in.	19·0	17

Dosage.—The water is given in small doses, gradually increased up to 10 oz., three or four times a day, on an empty stomach. It is essential that it should be fresh and hot from the spring, as, after standing and cooling, decomposition of the sodium-sulphide takes place and the water becomes insufferably nauseous. When fresh, however, nearly all patients rapidly get to tolerate it, and very many to enjoy it.

Indications.—It is specially indicated in hyperacidity, in flatulent dyspepsia, in intestinal auto-intoxication, and in gout, and particularly in cases of gout with a ready tendency to acute attacks. In these latter cases a stronger alkaline water, such as the sodic bicarbonated Te Aroha water, is peculiarly prone to set up either the condition described by Haig* as collæmia, with headache, lassitude, cold extremities, and slow capillary reflux, or to precipitate an acute attack of gout in a joint. It is given, too, in syphilitic cases, with the simultaneous employment of douche massage, sulphur vapour baths, and mercurial treatment, with the idea of saturating the system with sulphur.

It is claimed that the sulphides in mineral water hasten the metabolism of mercury in the system, and enable large doses to be put through with enhanced rapidity and with less risks of cumulative effects.

Such a water, on account of its combination of bland physical properties and antiseptic power, should make an ideal medium for intestinal lavage by the Plombières method.†

External Use.—The water is used for swimming-baths, immersion baths, and douches.

* " Uric Acid in Causation of Disease."

† This treatment is being introduced as this work goes to press.

Swimming-baths are, of course, not intended primarily for therapeutic use, but swimming in hot water is really an invaluable aid in many arthritic cases, not only by enabling otherwise crippled patients to take active exercise, but in making stiff joints supple. The abduction of the hip-joints in swimming is especially valuable.

Immersion-baths.—All the effects already described* of immersion in hot water can be obtained by immersion in Rachel water, but where the specific effects of mineral water, as such, are required, the acid waters are so infinitely more potent that the Rachel water is little used.

Rachel baths are indicated, however—(1.) In most cases of skin-disease that will stand baths at all, and this includes the bulk of skin cases, with the possible exception of those exhibiting large bullæ, very acute dermatitis, and such acutely infective lesions as tinea tonsurans: immersion should be prolonged, and special precautions should be taken afterwards to protect the skin; therefore facial cases are obviously contra-indicated.† (2.) Where a sedative effect is desired, as in insomnia, the temperature of the bath being then maintained at about the body-temperature or a little lower—the so-called "neutral bath." (3.) In cases, not uncommon, where the patient's skin is intolerant of the acid baths. (4.) As a vehicle for the electric current in the electric bath.

Douches.—It is, however, in douche form that this water is most useful, for here its physical properties render it an ideal agent. The alkaline silicate makes the water bland and, in combination with the sebaceous coating of the skin, almost slippery, so that for the combination of douche and massage known as *Aix-douche* it is invaluable.

In douche massage the force of the water (about 30 lb. to the square inch) materially aids the masseur's fingers, and, indeed, constitutes a form of massage as it impinges on the skin. Also, by directing the stream on to certain prescribed areas, the special reflex effects described on pages 21, 22 are set up, and these effects can be enormously increased by the use of the *Scotch douche*‡ of alternating hot and cold water. When the relief of pain is more especially aimed at, or derivative effects on the circulation are desired—*e.g.*, in cerebral or hepatic congestion—the *revulsive douch*

* *Cf.* page 16 *et seq.*

† *Cf. page* 21.

‡ Strictly speaking, the Scotch douche consists of a single long application of hot douche followed by a single shorter cold application, the rapidly alternating hot and cold douche being known as the *alternate douche.* At Rotorua, however, the term "Scotch douche" covers both.

is used. The skin correlated with the part affected is treated by the prolonged use of a very hot douche, followed by a momentary application of a cold one, to be again followed, if necessary, by hot. The water is also in constant use as the *undercurrent douche* in immersion-baths, being applied by an underwater hose at a higher temperature than the bath and with considerable force.

Both the force and temperature at impact can be easily modified by moving the douche-nozzle nearer to or farther from the part treated. This is an invaluable agent in the treatment of sciatica.

Indications. — Douche massage is contra-indicated in most acute conditions, but is invaluable in almost all others for which balneological treatment is indicated, and especially in the treatment of adhesions of all sorts, such as stiff joints at any stage below that of bony ankylosis, fibrositis, and adherent tendons. By its profound stimulation of local circulation it promotes local metabolism, the absorption of exudates, and the regeneration of tissue.

There is no agent so valuable for the restoration of mobility of the limbs after surgical operations, and after fractures and dislocations. Through its reflex effects it is invaluable in the treatment of atonic conditions of the viscera, and partly through relieving these conditions, and partly by direct stimulation of the nervous system, it is one of our most efficacious weapons in fighting neurasthenia.

The Acid Sulphur Waters.

In violent contrast to the above are the acid suphur waters. Except that they are more siliceous, the alkaline sulphur waters fairly closely resemble the widely distributed sulphur waters of Europe. The acid sulphur waters would appear to be without any European prototype, the only waters approaching them being certain waters in Japan and in the United States.*

These waters ooze rather than gush from the ground, and their temperature, in the Rotorua district at any rate, never approaches that of the alkaline waters, being generally between 110° and 150° F.

The most strongly acid waters of New Zealand rise in volcanic White Island, in the Bay of Plenty—waters far too corrosive to use; the next strongest at Taheke, twelve miles from Rotorua; the next in Whale Island, in the Bay of Plenty; and next come the waters of Rotorua.

* The Iowa acid springs contain 409 grains, and the Oak Orchard acid springs, New York, 134 grains $H_2 SO_4$ per gallon.

Rotorua is a lake, roughly circular in shape and about six miles in diameter, lying in a great basin surrounded by hills. Between the shores of the lake and the hills is a pumice plain, fairly extensive towards the south-west, and apparently the bed of an older and larger lake. On this plain the town of Rotorua is built, and on the margin of the lake rise the acid springs. Underlying the pumice bed, at any rate in the neighbourhood of the springs, is a bed of fine white clay.

In places this outcrop is at the surface, in others it is covered by 20 ft. of pumice-gravel, and in such areas the subsoil water is a hot solution of dilute sulphuric acid, which rises and falls with the lake-level, and in places breaks through as a hot spring accompanied by various gases, notably CO_2, H_2S, SO_2, and nitrogen.

The genesis of this acid water affords scope for interesting speculations, which need only be summarized here. Briefly, I believe the acid-water to be metamorphosed alkaline-water which has escaped into the subsoil, where it is mixed, or at any rate is hydrostatically connected, with the lake-water. Here, partly by the oxidation of sulphides, partly by the decomposition of marcasite (disulphide of iron), which is abundantly present, but chiefly by the bubbling through it of SO_2, sulphuric acid is formed, which in turn acts on the clay substratum (hydrous aluminous silicates) to form alum. The result is a water containing, amongst other things, sulphuric acid, ferrous sulphate, and aluminium sulphate. This water, of a beautiful clear green when fresh, rapidly grows cloudy from oxidation on standing, and becomes covered with a floating pale film of sulphur. The water in those springs through which CO_2 bubbles freely retains its sparkling clarity; in others, in which the gas is nearly absent, it rapidly becomes cloudy.

Uses.—The water is unfitted for internal use and is employed for bathing only. Owing to its irritating properties its use in douche form is limited to the undercurrent douche and to a douche for the back, but these same properties render it specially valuable for immersion baths.

A few minutes' immersion in one of the acid baths causes a bright scarlet hyperæmia of the skin, the contrast between the red area of wetted skin and the pale skin of the bather above the water-line being quite vivid.

For reasons already stated (p. 22, effects of acid water on the blood count), I believe this hyperæmia to be an active arterial one, and that it is this active hyperæmia which constitutes the essential value of these waters.

There are three main springs at present used for bathing purposes—the Postmaster, the Old Priest, and the New Priest springs.

Analyses of Acid Waters.

—	Postmaster Spring (Analysis, 1906).	Old Priest Spring (Analysis, 1906).	New Priest Spring (Analysis, 1908).
	Grains per Gallon.	Grains per Gallon.	Grains per Gallon.
Potassium-chloride ..	2·00	0·94	2·68
Sodium-chloride	8·89	7·03	15·10
Sodium-sulphate.. ..	14·25	10·85	19·94
Aluminium-sulphate ..	15·60	9·60	12·38
Ferrous-sulphate.. ..	0·52	0·06	1·30
Calcium-sulphate ..	6·25	6·46	4·85
Magnesium-sulphate ..	1·91	1·68	0·60
Silica	15·11	12·10	22·82
Sulphuric acid (free) ..	22·29	3·77	16·80
Total	86·81	52·49	96·47
Gases: free CO_2 and H_2S ..	Fairly abundant	Fairly abundant	Comparatively scanty
Temperature	98° to 120° F.	98° to 120° F.	130° to 160° F.

The Postmaster Bath.—This somewhat primitive but very valuable bath consists of a number of square timber-lined excavations over the actual springs, surrounded by dressing-boxes, and open to the sky. This arrangement is rendered necessary by the very potent nature of the gases, principally H_2S and CO_2 which bubble up through the floor of the baths. Even so, incautious bathers are not infrequently overcome by the gases and have to be hastily withdrawn from the water by the attendant. Unconsciousness, with stertorous breathing and clonic spasm, comes on with startling rapidity, but passes off after a few minutes' exposure to fresh air. As a rule little after-results are noticeable, beyond an increased susceptibility to the fumes.

Three baths are reserved for men and three for women, their temperature varying from about 99° to 108° F. or even 110° F. The latter, and hottest, bath approximates to the Japanese type.

The advantages of bathing in the actual springs are that no radio-activity is lost from the water, except, of course, into the atmosphere,* and that the stimulus of ionized gas is obtained as it bubbles through. In addition, these open-air baths are incomparably more stimulating than those in closed bathrooms.

The disadvantages are the toxic nature of the gases, the impossibility of accurately graduating the temperature of the bath, the contamination of one's bath by another bather, and the absence of undercurrent douches.

* *Cf.* page 61, on the advantages of small closed bathrooms in dealing with radio-active waters.

The bath can be used in two distinct ways—(1) A short immersion, a very high temperature, and a following cold shower cause active hyperæmia and distinctly *tonic* effects; (2) a longer immersion at a somewhat lower temperature, followed by a douche of warm alkaline sulphur water, is used where relief of pain and stiffness is the most urgent indication. Or, again, a single limb or part of a limb may be immersed, for, say, twenty minutes, to get the maximum passive hyperæmia of Bier, while the body as a whole is treated by the tonic first method.

Every gradation between the two methods may be used according to the condition of the patient and the exact object in view. It is always advisable to finish up with either a hot alkaline douche or a cold shower, so as to wash off the irritating acid-water from the skin.

Indications.—This bath is invaluable in all chronic arthritic conditions, in "lumbago," and sciatic perineuritis or neuralgia. It is useful, too, as a depletive of congested internal organs in defective circulation not due to heart-disease, and as a general tonic.

Contra-indications.—It is contra-indicated in feeble patients, in heart cases, and in skin-diseases; and many persons with apparently normal skins are unable to use this bath, or, indeed, any of the acid baths, on account of the supervention of a very irritating and obstinate papular rash. In the same way, in any of the acid baths, a slight abrasion may develop into an intractable ulcer, reminding one, in its obstinate resistance to treatment, of a mild X-ray burn.

The Priest Baths (Old).—These closely resemble, both in the constitution of the waters and in construction, the Postmaster Bath. The water is considerably weaker in sulphuric acid and in toxic sulphurous fumes, but richer in CO_2.*

The amount of CO_2 varies very considerably in different baths, being much more abundant in the ladies' establishment; it also varies in quantity from day to day. The temperature of the baths also varies very widely both in different baths and in the same bath at different times, apparently from movements of cold subsoil water and from varying admixture of lake-water in the springs. The hottest bath is on the men's side, where the thermometer frequently registers 108° F., the coldest on the women's, where it may be as low as 85° F.

In a general way, all that has been written about the Postmaster Bath applies equally to the Priest, except that, the water

* The percentage composition of the gases (Dr. Maclaurin, 1911) is as under: Carbon-dioxide, 84·5; sulphuretted hydrogen, 6·5; nitrogen, 9·0: total, 100.

being less acid, the bather's skin is less apt to be irritated, and, the fumes being less potent*, there is less risk of asphyxial attacks. On the other hand, the therapeutic efficacy is less than that of the Postmaster. Numbers 1 and 2 on the ladies' side, however, are in a class by themselves. Here the water is cooler (85° to 100° F.), perfectly clear, and very free effervescence of CO_2 comes from the pumice floor of the baths.

On entering the bath there is first a sensation of chilliness, which gradually becomes replaced by a glowing warmth† due to the stimulation of bubbles of CO_2, the skin becomes bright scarlet from *active* hyperæmia, the cutaneous blood shows a considerable increase in the count of both red and white cells, and there is vigorous contraction of the cutaneous unstriped muscles. Thus, in a male bather, the contraction of the dartos is so vigorous after a few minutes as to become painful. Practically the effects of a Nauheim bath result—a stimulation of the peripheral circulation, of the " skin heart "—the dilute sulphuric acid replacing the brine of the Nauheim bath.

Indications.—The Priest baths are indicated in the same class of cases as the Postmaster, but are less potent and safer to use. The effervescent Priest baths are more especially indicated where a tonic effect is desired, such as in chlorosis, and anæmic, rheumatoid, rheumatic, and neurasthenic cases, with moderately sound hearts. As at present arranged, they are hardly suited for cases of dilated heart.

The Priest Bath (New).—A large number of private and three public baths are fed by the spring supplying the New Baths. The public baths are kept at 104° F. (men's) and 103° F. (women's). The private baths can be obtained at any desired temperature, as the water is pumped from the spring at about 130° F. and arrives in the building at about 115° F.

Every bath is supplied with an undercurrent douche, and, in addition, there are hot and cold showers of Rachel and plain water, and overhead Priest water douches.

Comparative Value of the Old and New Baths.—The New Priest water is a little weaker in sulphuric acid than the Postmaster, but a great deal stronger than the Old Priest spring, but free gas is absent, and radio-activity less marked. The stimulus of ionized gas is also lost, and the general effect is less tonic; but on the other hand there is complete freedom from risk of gas asphyxia,

* In the Postmaster there would appear to be a larger proportion of H_2S, which, being lighter than the CO_2, does not lie in such a shallow layer on the surface of the water, and hence is more apt to be inhaled by the bather.

† See page 14 on the indifferent temperature of gases.

the temperature of the bath can be accurately prescribed, the patient is assured of uncontaminated water and of privacy, and the undercurrent douche is available.

The undercurrent douche is invaluable in cases of sciatica and in stiff and painful muscles where some massage is required. This massage action of the douche is very pronounced and can be readily appreciated when its action is watched. With the nozzle placed, say, 4 in. from the thigh, a circular depression, about 1½ in. across and from ½ in. to ¾ in. deep, is seen to form in the skin, and by moving the douche every part of the surface immersed can be very effectually massaged.

Indications.—As for the Postmaster, but, owing to the absence of toxic fumes and the possibility of the recumbent position, the baths can be safely used in cases in which the old baths would be contra-indicated. Recently, also, I have used these Priest baths in the treatment of chronic dry eczema and psoriasis with marked benefit. It would appear as if the water stimulated the skin in much the same manner as such lotions as liq. carbonis detergens, while possibly the alum present subsequently acted as an astringent on the inflamed areas as the primary hyperæmia passed off.

Mud Baths.—The material used is the clay deposit collected from one of the hot mud springs of the district, and liquefied and heated again by steam.

These hot mud springs appear to be caused by the continuous upward passage of steam and sulphurous gases through the clay stratum which underlies the pumice and sand of the Rotorua basin.

The material is homogeneous and free from grit, and distinctly greasy to the feel. It is composed principally of silicates, with a large admixture of free sulphur, and is radio-active.

It will be observed that the mud baths of Rotorua are essentially different from the peat baths—the moorbäder—so much used in Europe, and closely resemble the "fango" baths of Italy, such as those of Acqui and Battaglia, or the mud baths of Dax.

In contradistinction to what is said to be the custom at some of the European spas, however, the mud is never "cooked up again" and used twice. It is given in a full reclining bath of a consistency of from pea-soup to thin gruel, followed by a circular needle-douche of Rachel water and a hot pack, or locally in poultice form. The temperature can, of course, be varied at the discretion of the prescriber, but I have found the higher temperatures 104° or 105° F. more efficacious than the lower.

Owing to the low conductivity of the medium, the bather's temperature rapidly rises, and to this rise of temperature, to the

rapidly induced skin hyperæmia, probably caused by the free sulphur present, and to the demulcent effect of the bland siliceous material, are due the alterative and pain-relieving properties of the bath. Possibly, too, the radio-active* nature of the mud is also a factor.

Analysis.

	Per Cent.
Silica	69·30
Alumina	4·52
Iron-oxides	2·00
Titanium-oxide	0·58
Lime	1·00
Magnesia	0·10
Soda and potash	1·30
Sulphur (conbined)	1·40
Sulphur (free)	6·09
Organic matter	10·01
Water	3·70
	100·00

Also traces of gold and silver.

Indications.—For the relief of pain and stiffness in gouty and rheumatic cases in which acid baths are found too irritating to the skin, or where purely sedative effects are desired, the mud baths are extremely useful. Personal idiosyncrasy, or perhaps some unrecognised peculiarity in the phase of disease, would also appear to come in, for many patients experience immediate relief from a mud bath, while apparently identical cases do better with a Priest bath.

The mud, too, would appear to have a specific action in many skin cases, especially psoriasis and dry chronic eczema. Remembering the antiseptic properties of both sulphur and the silicates, and the bland physical properties of the latter, it is not surprising that the mud should form an ideal ointment.

For the sake of the comfort of the patient, the mud is generally washed off after a twenty minutes' immersion, but I am frequently in the habit of leaving it on to dry, where a portion only of the body is involved, to form a protective coating.

Contra-indications.—On account of its sedative and rather relaxing action, the mud bath must be used with caution in debilitated subjects, such as those suffering from acute rheumatoid arthritis, and in skin cases exhibiting deep bleeding fissures it may perhaps mechanically interfere with their healing.

* *Cf.* page 87.

Like all other forms of bath treatment, it is, of course, an unsuitable medium for treating disease of the skin of the face.

Vapour Baths.—The hot-vapour room, " Russian Bath," is used as a common preliminary of the Aix Massage douche. The patient, after a preliminary spray with hot Rachel water, sits for a few minutes in the vapour-room (temp., about 110° F.). Here his temperature rapidly rises, thereby hastening metabolism, profuse perspiration is induced, and the tissues are relaxed in preparation for the masseur.

The *vapour-cabinets* at the new baths are supplied with sulphuretted steam from the Malfroy Geyser, and at the Blue Bath with hot SO_2 and steam from a sulphur-cavern. The patient may sit immersed to the neck (complete vapour bath), generally at a temperature of 110° to 112° F. ; or one or more limbs only may be treated (local vapour bath), at a temperature of from 120° to 130° F.

In the geyser vapour the effects are the same as those noted in the Russian Bath, with the exception that the respiration is not embarrassed to the same extent by the breathing of the hot moist air ; in the Sulphur Vapour Bath there are superadded the effects of nascent sulphur.* This is deposited thickly over the inner surface of the cabinet, and more sparingly over the body of the patient, by the decomposition of the sulphurous acid.

The skin is intensely reddened, active hyperæmia as well as passive taking place, and a certain amount of sulphur apparently is absorbed by the unbroken skin, as is evidenced by the evolution of sulphides in the sweat some days afterwards.

Indications.—Such a bath as the Sulphur Vapour would, of course, be an ideal medium for the treatment of scabies, though for the peace of mind of other bathers its use for this purpose is not encouraged ; it is also indicated in the same class of cases as the Postmaster Bath (page 81), and has the advantage in certain cases of causing more muscular relaxation and relief of stiffness. It is especially useful in syphilitic cases in which free absorption of sulphur is desired to promote the metabolism of mercury,† and in cases of acne.

Locally, it is invaluable in promoting absorption of synovial fluid and for softening adhesions prior to passive movements.

The physiological action is—increased local temperature, with increased metabolism ; local passive hyperæmia, with increased phagocytic activity, effects which are now familar through the

* *Cf.* The observation of Dr. F. W. Smith on the effects of the deposition of nascent sulphur at the anode in Harrogate waters, B.M.J., Feb. 16, 1901, and *Lancet,* Aug. 10, 1901 : quoted by Weber.

† *Cf.* Rachel water, page 74.

teaching of Bier; and local arterial active hyperæmia from the stimulation of SO_2 and nascent sulphur, with the regenerative effects of increased arterial supply.

Contra-indications (*complete immersion bath*).—Febrile cases, cardiac weakness, advanced arteriosclerosis or renal disease, and pulmonary tuberculosis.

Inhalation.—An apparatus was installed for giving the vapour from the Malfroy Geyser as an inhalation in laryngeal and bronchial cases. The chemically interesting, but therapeutically disconcerting, discovery however was made that, in its passage of 200 or 300 yards from the geyser to the baths, the mixture of sulphides and steam underwent oxidizing changes, part of the sulphides being converted into sulphurous acid and the vapour becoming so irritating as to be irrespirable. The possible bearing of this on the formation of sulphuric acid in the district is noteworthy.

A good deal of involuntary inhalation of sulphuretted hydrogen and other gases goes on during bathing (*cf.* Postmaster), but probably with no therapeutic advantage.

Radio-activity of the Mineral Waters.

The question of radio-activity has already been touched upon (see chapter V). An examination of a number of waters was made by Dr. Maclaurin in 1911, which showed that their radio-activity was relatively low as compared with that of many well-known waters in other parts of the world. It may be that the excessively high temperatures of most of the waters conduces to a very rapid loss of emanation; at any rate, the cold non-mineralized springs rising in the same district showed a higher activity.

The following tables show the activity as expressed in billionths of a gramme of radium per c.c. :—

Table I.—Radio-activity of Gases.

Source.	Location.	Activity.
Old Priest Bath	Rotorua	0·170*
Gas spring in Lake Rotorua ..	,, ...	0·697
Waitangi Spring	Rotoehu	0·021

* Little more than 0·3 Maché units.

Table II.—Radio-activity of Waters.

Source.	Location.	Temperature (Centigrade).	Activity.
Rachel Spring*	Rotorua ..	90 to 100	0·0920
,, †	,, ..	90 to 100	0·0890
Old Priest Bath*	,, ..	38	0·1310
,, †	,, ..	..	0·1090
Postmaster Bath†	,, ..	40	0·0100
New Priest Spring*	,, ..	40	0·0320
Ditto, from tap in bath-house ..	,, ..	..	0·0250
Malfroy Geyser	,, ..	Boiling	0·0015
Boiling lake opposite Spout Bath	Whakarewarewa ..	,,	0·0160
Hamurana* (not mineral water)	Rotorua ..	11·5	0·3490
Fairy Spring* (not mineral water)	,, ..	14·0	0·3090
Soda Spring..	Waitangi, Rotoehu	40	0·0110
Champagne Pool*	Waiotapu ..	72	0·1470
,, *	Wairakei ..	Boiling	0·0080
,, †	,, ..	,,	0·0100
Great Wairakei Geyser† ..	,, ..	,,	0·0050
Witchs' Cauldron†	Taupo	,,	0·2040
No. 2 Spring	Te Aroha ..	38·0	0·0260
No. 6 ,, ...	,, ..	35·0	0·0150
No. 8 ,, ...	,, ..	42·0	0·0100
No. 15 ,, ...	,, ..	50·0	0·0310
No. 20 ,, ...	,, ..	18·0	0·0560
No. 22 ,, ...	,, ..	21·0	0·1300

Table III.—Radio-activity of Mud used in Mud Baths.

Source.	Location.	Activity.
Mud from boiling-mud spring ..	Rotorua	0·091
Mud in use in baths	..	0·185

* Waters examined in the field.
† Waters examined about eight months after in the laboratory by a more sensitive electroscope of the Joly type.

It will be noted that the mud in use at the baths showed a higher activity than that collected fresh from the spring. The former consists of dry deposit from the margins of a boiling-mud spring, artificially made pultaceous by steam.

It will be recalled that radio-activity was discovered in the calcareous and other deposits round some of the European springs before it was detected in the actual waters.

The same relative radium richness is found in the sinters round the New Zealand springs (Table V) as in the dried deposits round the boiling-mud holes.

Table IV.—Radium-content of Waters.

Source.	Location.	Activity.
Rachel Spring	Rotorua	0·0004
Old Priest Bath	,, ...	0·0003
Hamurana	,, ...	Nil.
Waitangi	,, ...	,,
Champagne Pool	Waiotapu	0·0002
,, ...	Wairakei	0·0003
Great Wairaki Geyser	,, ...	0·0005
Witchs' Cauldron	Spa, Taupo	0·0005
No. 2 Spring	Te Aroha	0·0009
No. 6 ,, ...	,, ...	0·0002
No. 8 ,, ...	,, ...	0·0001
No. 15 ,, ...	,, ...	0·0012
No. 20 ,, ...	,, ...	0·0005

Comparing this table with Table II, Dr. Maclaurin points out that only a very small part of the emanation found in any of the samples is due to radium contained by the waters.

Table V.—Radium-content of Sinters.

Source.	Location.	Content.
Rachel Spring	Rotorua	0·72
Boiling Lake	Whakarewarewa ..	1·03
Waikite Geyser	,, ..	0·41
Small geyser	Waimangu	1·55
Champagne Pool	Wairakei	0·46
Prince of Wales' Feathers Geyser ..	,, ...	0·91

CHAPTER VII.

ANALYSIS OF CASES TREATED AT ROTORUA.*

In view of the very large number of cases passing through one's hands at Rotorua, and the opportunities so afforded for statistical purposes, it may not be without interest to pass them in brief analytical review. Such a review is facilitated by the fact that, foreseeing the present inquiry, I have retained notes on the questions I wanted to elucidate in some eight thousand consecutive cases in private practice, though, to ensure accuracy, I have only utilized here the figures of the last three years, which were obtained with special care. Such a review will, at any rate, give some idea of the comparative incidence of the various diseases amongst those who seek spa treatment, and will also roughly indicate other more important points, such as the influence of heredity in arthritic diseases, the comparative frequency of previous acute rheumatism, the results of treatment in different diseases, &c.

The accuracy and value of such statistics must, however, always be very largely discounted by the fact that personal medical histories are unreliable even in educated people, and still more so in the uneducated, and that this applies with tenfold force to " family histories."

Again, in regard to the relative frequency of incidence of various diseases, the figures do not necessarily indicate the rate of prevalence in New Zealand, as it must be remembered that the patients have been drawn from the four quarters of the globe ; and, though some two-thirds of the total were resident in this country, yet of these residents probably at least one-third were not New-Zealand born, especially as a large proportion of them were elderly.

Before instituting a comparison of the relative frequency of the various diseases, one must make perfectly clear the meaning of the terms employed in nomenclature. This is especially true of the arthritic diseases, as nowhere else in medicine is there such a confusion of terminology. Thus the unqualified names " gout," " rheumatism," and " rheumatoid arthritis " are almost without meaning, for they may bear such absolutely different interpretations to different readers. I propose, therefore, to define briefly what sort of cases have been included under these various headings.

Probably half my readers will totally disagree with the interpretation here adopted of those terms, and, indeed, it would be quite impossible to adopt any system of classification that would

* This analysis includes Sanatorium in-patients and out-patients treated in private practice.

not be disclaimed by a large and influential minority. Still, having clearly defined what cases are included under each heading, there can be no misconception, and the statistics will be less fallacious.

The conception of arthritis as a symptom of many diseases rather than as an entity produced always by the same specific cause is becoming more generally realized. It has long been recognized that a specific arthritis may result from tubercular, gouty, rheumatic, syphilitic, gonorrhœal, typhoid, and pneumo-coccal infections, and I have here recorded several cases of arthritis after true dysentery; but it is only in recent years that we have realized that many of the common and apparently trivial departures from health may cause severe and intractable arthritis—intractable, that is, until the exciting focus of disease is removed. Thus many septic oral conditions, such as abscesses about the roots of the teeth,* pyorrhea alveolaris, and tonsilar infections, may cause, apart from acute suppurative arthritis, a multiple arthritis closely resembling true rheumatoid; so also may chronic infection of the nasal sinuses, of the pelvic organs, and, indeed, of any part of the body. Again, absorption of toxins from the intestinal tract may produce fibrositis and arthritis of a type absolutely indistinguishable from chronic "low" forms of gout.

Apart from bacterial infection and intoxication, it is probable that abnormalities of metabolism in connection with puberty, pregnancy, and the menopause, and unstable conditions of the nerve-cells controlling joints, may initiate a chronic arthritis.† In all these cases there would appear to be a disease which is not a true specific entity, or, rather, a number of diseases of mixed and varying causation, but with common symptoms, of which arthritis is a predominant one, and some authorities would include true rheumatoid arthritis in this class. The very constant and clear-cut nature of the symptoms of this complaint, however, certainly point to it being a definite entity due to a specific and unvarying infection: it is a disease whose symptoms, at any rate "breed true."

Omitting from consideration tubercular joint disease and such rare conditions as Charcot's arthritis, and considering only the cases generally vaguely called "rheumatic," these have been classed as follows:—

1. **Acute Rheumatism.**—As there is no serious controversy as to what is meant by rheumatic fever, no precise definition of terms is necessary. Under this heading is included "subacute rheumatism" and the very atypical attacks that occur in childhood, but which nevertheless cause endocarditis. Assuming the

* At the Sanatorium tooth-brushes are provided for poorer patients as essential parts of the treatment.

† Compare Marshall: Boston Med. and Surg. Journal, Dec. 29, 1910.

disease to be due to an invasion by micro-organisms,* it is obviously impossible to separate the milder infection of a subacute attack from the acute specific fever. On the other hand, it is also difficult to differentiate a subacute attack of rheumatic from one of other organisms, except perhaps by the doubtful method of reaction to salicylates, or in some cases by the reaction to vaccines.

2. **Chronic Rheumatism.**—Practically this term has been here almost eliminated. The word has been used so loosely as to have lost all meaning, and until a clearer conception has been gained as to what is really meant by the term it seems to me that it would be better to discontinue it. The same remarks apply with even greater force to the term " muscular rheumatism," which generally means a vague pain, not in the joints, and of undiagnosed origin. The only cases here classified as " chronic rheumatism " are those in which there has been acute rheumatism with incomplete recovery or frequent relapses.

3. **Gout.**—Assuming gout to be an intoxication with substances of the purin and nucleo-protein series, attended by, but not necessarily entirely caused by, an excess of uric-acid salts in the body, and manifesting itself in most varied forms, a vast number of conditions have been classed under this heading which many or most people would label " chronic rheumatism." Thus almost all cases of chronic rheumatic arthritis not preceded by acute rheumatism have been put down here as gouty, and all cases of muscular rheumatism and fibrositis not definitely proved to be infective.

Certain symptoms of disease, by reason of their frequency, and by reason of the fact that from long custom we have come to look upon them as if they were a *disease* and not a symptom, have for convenience been classified separately. Thus, sciatica may be a symptom of gout or it may be due to trauma, and in the former case ought no more be labelled as a separate disease than, say, gouty arthritis of the great toe.

Where cases have been classified as sciatica, that symptom has been so overwhelmingly prominent as to mask all others. This is not, of course, a very scientific form of classification, but it is a convenient compromise.

Lumbago is another symptom, generally gouty, often labelled as a separate disease, and where dignified with a separate column in these statistics indicates a symptom as prominent and exclusive as in the case of sciatica, as indeed is evident from the small proportion of cases included under this heading.

* Probably the streptococcus rheumaticus of Poynton and Paine. Apparently, however, this organism was first described by Mantle, B.M.J., June 25, 1887. For a complete bibliography of the subject see Guy's Hos. Reports, Vol. 45, p. 193 (Sandison).

4. **Rheumatoid Arthritis.**—Under this heading are included only cases conforming strictly to a definite clinical type as under. A multiple quasi-symmetrical arthritis, occurring chiefly in young female subjects, characterized by soft spindle swellings of the middle joints of the fingers (more rarely of the thumbs, in contradistinction to gout). The wrists, elbows, ankles, knees, temporo-maxillary joints, and cervical spine are especially affected. The hips are very rarely damaged (in contradistinction to osteo-arthritis), and then only in very advanced cases. In addition, there are anæmia, tacchycardia, often a slight muffling of the first cardiac sound at the apex, cachexia, and certain trophic changes, such as pigmentation in the form of pin-head dark-brown spots and large diffuse washes of paler brown, a tendency to brittle and often pigmented nails, cold sweating palms, and a thinning of the ends of the bones in affected joints.

In contradistinction to osteo-arthritis, there is no tendency to bone-proliferation, and the X-ray picture of an affected hand is almost pathognomonic* (*vide* figs. 8 and 9).

In rare cases the diagnosis between this disease, gonorrheal arthritis, and asthenic gout is doubtful, but the X-rays and reaction to vaccine will generally determine the matter. The disease is probably an infection, accompanied by marked trophic phenomena.

5. **Osteo-arthritis.**—I look upon this condition not so much as a definite disease, but as one of the reparative processes of nature which may ensue after rheumatism, gout, rheumatoid arthritis, or traumatism—as an end-change of all. The characteristic of the condition is bone formation rather than destruction, and the X-ray picture is entirely distinctive from that of rheumatoid arthritis (compare figs. 9 and 11). One joint may be affected, or many, according to the number of joints damaged by some previous disease and to the reactive power of the individual. Thus it is very common in the hip-joint (*cf.* rheumatoid), a joint specially liable to wear-and-tear and to subacute attacks of what is generally called chronic rheumatism, but which here is called gout.

It has been said that arterio-sclerosis is a cause of osteo-arthritis, but would it not be more correct to say that it is a frequent concomitant—that the same underlying causes predispose to both? Clinically, the picture of osteo-arthritis will largely depend upon the antecedent disease on which it has been superimposed. Thus,

* For a full account of the X-ray appearances see "Disease in Bone," by E. W. H. Shenton. Macmillan, 1911. In rare cases, according to Kienbock, rarefaction of the articular ends of bones may occur. It may certainly do so in tubercular disease (see fig. 17).

supervening on a case of rheumatoid arthritis there may be spindle fingers, no longer caused by soft synovial swellings with atrophic bone endings, but hard from proliferation of the bone endings (*vide* fig. 10) ; while in a case supervening on gout, there may be masses of bone in the place of old uratic deposits—for instance, at the bases of the phalanges—and causing great deformity or even dislocation (*cf.* figs. 11, 12, 13).

Again, the skeleton of the tailor, the cobbler, the coal-miner will show unmistakable evidences, in the indelible handwriting of osteo-arthritis, of the former occupation of its owner.

6. Gonorrheal Arthritis.—In my experience, no cases of arthritis present such frequent difficulties of diagnosis and definition as this complaint, the more so from the enormous frequency of a history of gonorrhea in male cases, whatever their arthritic disease may be.

In its most characteristic form it attacks a peculiar and distinctive group of joints—*e.g.*, the knee, the temporo-maxillary, and the sterno-clavicular—in a young subject, and is especially apt to cause an intractable tenderness under the heel, often associated with a spur from the os calcis into the plantar fascia (*vide* fig. 14). There is frequently, too, a characteristic careworn facies, and there may be signs of recent or old iritis. In the atypical cases, however, there may be the most perfect mimicry of rheumatoid arthritis, and I have included in the list of gonorrheal arthritis several such cases which were only diagnosed by their reaction to vaccine and their X-ray appearance (*vide* figs. 15, 16).

I am convinced that several of my earlier-recorded cases of rheumatoid arthritis should have been put down as gonorrheal arthritis.

7. Miscellaneous Rare Forms.—There have been one or two cases of apparently syphilitic arthritis, and three cases of dysenteric arthritis. Dysentery was once common in Rotorua, but has now almost disappeared with improved sanitation. In all three cases of this arthritis that I have seen, the knee has been the joint affected.

The most serious case occurred in a man of fifty. He had severe dysentery, with pain and frequent blood and mucus stools, which he largely neglected in his anxiety for going on working. Acute synovitis of the right knee appeared towards the end of the attack, which eventually ended in fibrous ankylosis. Clinically the cases closely resembled gonorrheal arthritis.

Finally, while only a few cases were put down to infection from septic mouths, &c., there is no doubt that such infection was at any rate a contributory agent in quite a large proportion of the cases returned as gout and rheumatoid arthritis.

TABLE A.—ANALYSIS OF CASES TREATED AS IN-PATIENTS AT THE ROTORUA SANATORIUM DURING THREE YEARS AND A HALF ENDING JUNE, 1911.

(N.B.—The term " cured " is avoided as being hardly admissible when dealing with chronic and diathetic diseases. All cases generally classified in hospital statistics as " cured " are included under the term " Very much better.")

—	Better.	Much better.	Very much better.	Unchanged.	Worse.	Dead.	Total Number of Cases.
(a.) The " Rheumatic " Group (so called).							
1. Acute rheumatism and convalescence from acute rheumatism	4	10	36	..	..	..	50
2. Chronic rheumatism	4	6	10	1	..	..	21
3. Gout, including general " goutiness "	23	23	44	5	..	..	95
4. Rheumatoid arthritis (as defined, page 92)	12	10	11	6	..	..	39
5. Lumbago (*vide* page 91) ..	..	2	8	..	..	..	10
6. Osteo-arthritis	13	11	18	5	..	..	47
7. Spondylitis deformans ..	1	..	1	..	..	..	2
(b.) Non-rheumatic Arthritis, Bone-disease, &c.							
1. Gonorrheal arthritis—							
Treated also with vaccine* ..	3	3	14	1	1†	..	22 } 32
Treated without vaccine ..	2	1	7	..	..	..	10 }
2. Gonorrheal myositis	..	..	..	1	..	..	1
3. Tubercular arthritis‡	3	4	1	..	..	..	8
4. Traumatic arthritis	1	5	7	1	..	..	14
5. Septic arthritis (auto-intoxication from teeth, &c.)	1	1	12	1	..	..	15
6. Occupation arthritis (practically osteo-arthritis)	1	..	1	..	..	..	2
7. Syphilitic arthritis	1	..	1	..	..	..	2
(c.) Diseases of the Nervous System.							
1. Sciatica	12	9	40	4	..	..	65
2. Locomotor ataxia	1	2	1	1	..	..	5
3. Spastic ataxia and sp. paraplegia	4	..	..	2	..	..	6
4. Peripheral neuritis	5	1	8	2	..	..	16
5. Paralysis agitans	1	1	..	1	..	..	3§
6. Anterior polio-myelitis ..	1	..	1	2	..	..	4
7. Disseminated sclerosis ..	..	..	..	3	..	..	3
8. Spinal meingitis	1	1	1	2	..	..	5
9. Myelitis	..	..	1	2	..	..	3
10. Spinal hæmorrhage	..	1	1	..	..	..	2

* These cases were all treated first unsuccessfully by the usual methods, baths, hot air, &c., before being treated by vaccine. The Wimpole Institute stock vaccine in doses from 10 to 1,000 million was employed.

† Very profuse hæmaturia was set up after a full dose of 1,000 million, with granular casts in the urine, rigors, and hyperpyrexia.

‡ Excellent results were obtained, as experience with other hyperæmic treatment in tubercular infection would lead us to expect.

§ A large number of patients had also paralysis-agitans as a complication, but did not come for treatment of this disease.

TABLE A—*continued.*

—	Better.	Much better.	Very much better.	Unchanged.	Worse.	Dead.	Total Number of Cases.
(*c.*) *Diseases of the Nervous System*—continued.							
11. Spinal concussion	..	..	1	1	..	..	2
12. Pseudo-hypertrophic paralysis	..	1	..	..	..	..	1
13. Hemiplegia	6	2	5	2	..	..	15
14. Neurasthenia	15	11	21	3	..	..	50
15. Herpes zoster	..	..	..	1	..	..	1
16. Spasm of sterno-mastoid	1	..	..	..	..	..	1
(*d.*) *Diseases of Digestive System.*							
1. Gastric ulcer (convalescence)	..	..	6	..	..	..	6
2. Gall-stones	..	..	1	..	..	..	1
3. Appendicitis (chronic)	1	..	..	..	..	..	1
4. Chronic gastritis	..	..	3	..	..	..	3
5. Diabetes	..	1	2	1	..	..	4
(*e.*) *Diseases of the Skin.*							
1. Eczema	1	3	5	..	..	..	9
2. Psoriasis	..	3	7	..	..	..	10
3. Prurigo	1	..	..	..	..	..	1
4. Scleroderma	..	..	..	1	..	..	1
5. Syphilitic ulcers	..	..	1	..	..	..	1
6. Dermatitis (? cause)	..	..	..	1	..	..	1
Miscellaneous.							
1. Tubercle of spine	2	2	1	1	..	..	6
2. Tubercular ilium	..	..	1	..	..	..	1
3. Phthisis	1	..	..	..	..	..	1
4. Pes valgus	..	..	3	..	..	..	3
5. Talipes equinus	..	..	..	..	1	..	1
6. Old dislocations and fractures	3	2	..	..	..	..	5
7. Post-operative convalescence	1	..	1	..	..	..	2
8. Fibrositis (? gouty)	..	1	..	..	..	..	1
9. Renal calculus	..	..	..	1	..	..	1
10. Vesical calculus	1	..	..	..	..	..	1
11. Nephritis (chronic)	..	..	1	..	..	..	1
12. Asthma	..	..	1	..	..	..	1
13. Mitral regurgitation	1	..	..	..	..	..	1
14. Cardiac insufficiency	..	..	..	1	..	..	1
15. Post influenzal debility	..	1	..	..	..	..	1
16. Headache (? cause)	..	..	..	1	..	..	1
17. Hæmatoma	..	..	1	..	..	..	1
18. Morphinism	..	..	1	..	..	..	1
19. Thrombosis int. jugular	..	..	..	1	..	..	1
20. Traumatic periostitis	..	..	..	1	..	..	1
21. Sarcoma	..	..	..	..	1	..	1
22. Broken neck (with partial paralysis)	..	..	2	..	..	..	2
23. Arterio-sclerosis	1	1	..	..	..	..	2
Total	127	117	281	55	2	..	593

Analysis of some so-called Rheumatic Cases under Mineral-water Treatment at Rotorua in Private Practice during the Years 1909–11.

As in private practice patients may sometimes consult one only at the beginning of a course, it is impracticable to state definitely the results of treatment as in the case of hospital patients. Certain points of interest, however, are available for statistical purposes. Thus the influence of family history could, on the whole, be better elucidated than in the case of hospital patients: again, light might be thrown on the claim of certain symptom-groups and diseases, such as sciatica, gonorrheal "rheumatism," and rheumatoid arthritis, to relationship with true rheumatism and acute gout: again, the relative frequency of right and left sciatica could be definitely ascertained.

I had always an impression that left-sided sciatica was commoner than right: it will be seen that the impression was warranted, and, if any reason for this left-sided preference can be discovered, it may suggest some unsuspected factor in the ætiology, and consequently in the treatment, of this often baffling complaint.

Family History.—The frequency of a family history of gout or rheumatism in gouty or rheumatic cases is generally acknowledged. The present inquiry seeks to confirm or refute that opinion, and at the same time to demonstrate in which classes of cases such positive family histories most frequently occur. At the outset, however, we are met by considerable difficulties. Most people have but vague ideas as to the health of their relatives, so that a positive answer has to be discounted to some extent, and a negative answer to an enormous extent. Direct inquiry was made in every instance as to whether parents, grandparents, sisters, and blood-related uncles and aunts suffered from gout or rheumatism. At first an attempt was made to differentiate between the two affections, but, with even professional opinion still hopelessly divided over the nomenclature, it was impossible to expect any exact definition of terms from the layman, and the attempt was abandoned. A positive family history, then, means the known presence of either gout, rheumatism, or some disease taken to be one of them. Cases of merely senile arthritis are, as far as possible, excluded.

To obtain a larger sequence of cases, the figures for the years 1906–8 are also included in considering the rarer complaints, rheumatoid arthritis and gonorrheal arthritis. Two cases of syphilitic arthritis are included, but of course no general conclusions can be deduced from them.

FIG. 7.

Rheumatoid Arthritis. Note that the skin shows the natural wrinkles, and that the disease is therefore not in a very acute ingravescent stage; in the latter condition the tensely stretched skin would be more glossy, and the fine wrinkles would tend to be smoothed out.

[Face p. 92.

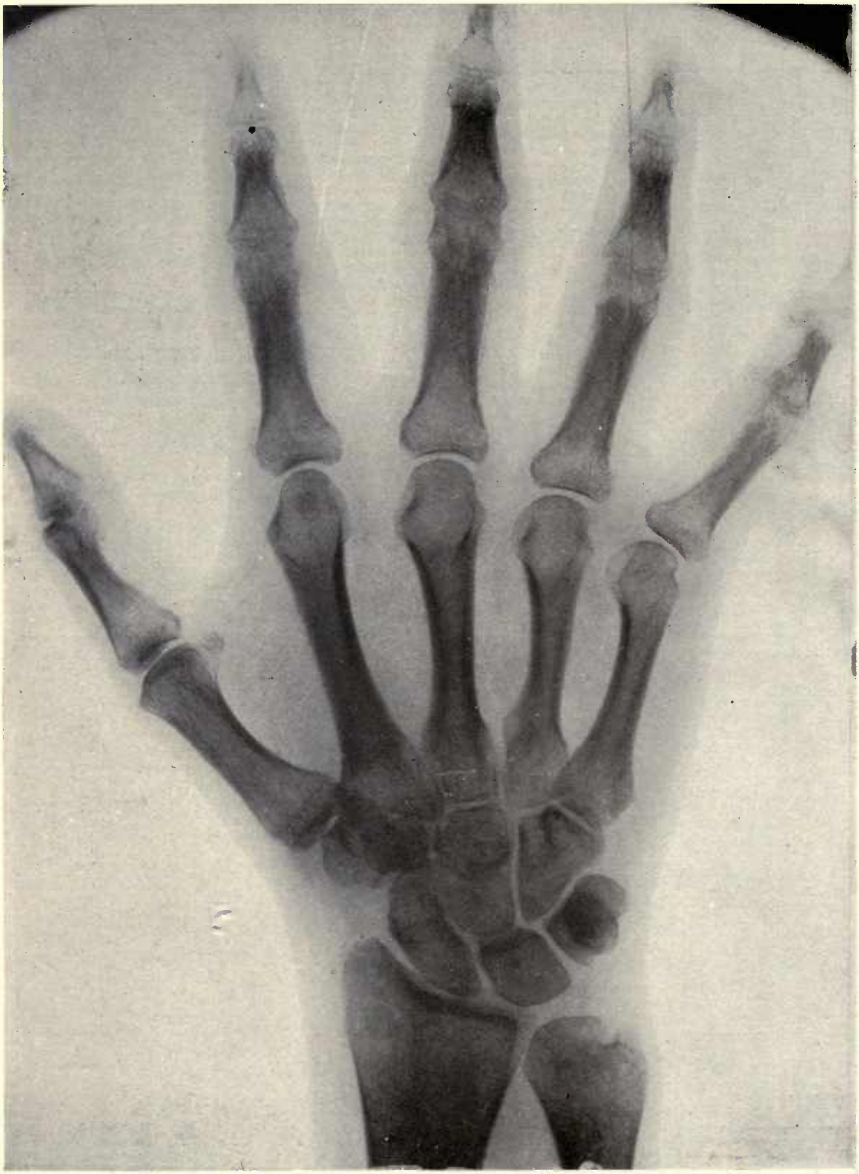


FIG. 8.

Rheumatoid Arthritis.—Early Stage.

Fig. 9.

Rheumatoid Arthritis.—Very Acute Case.

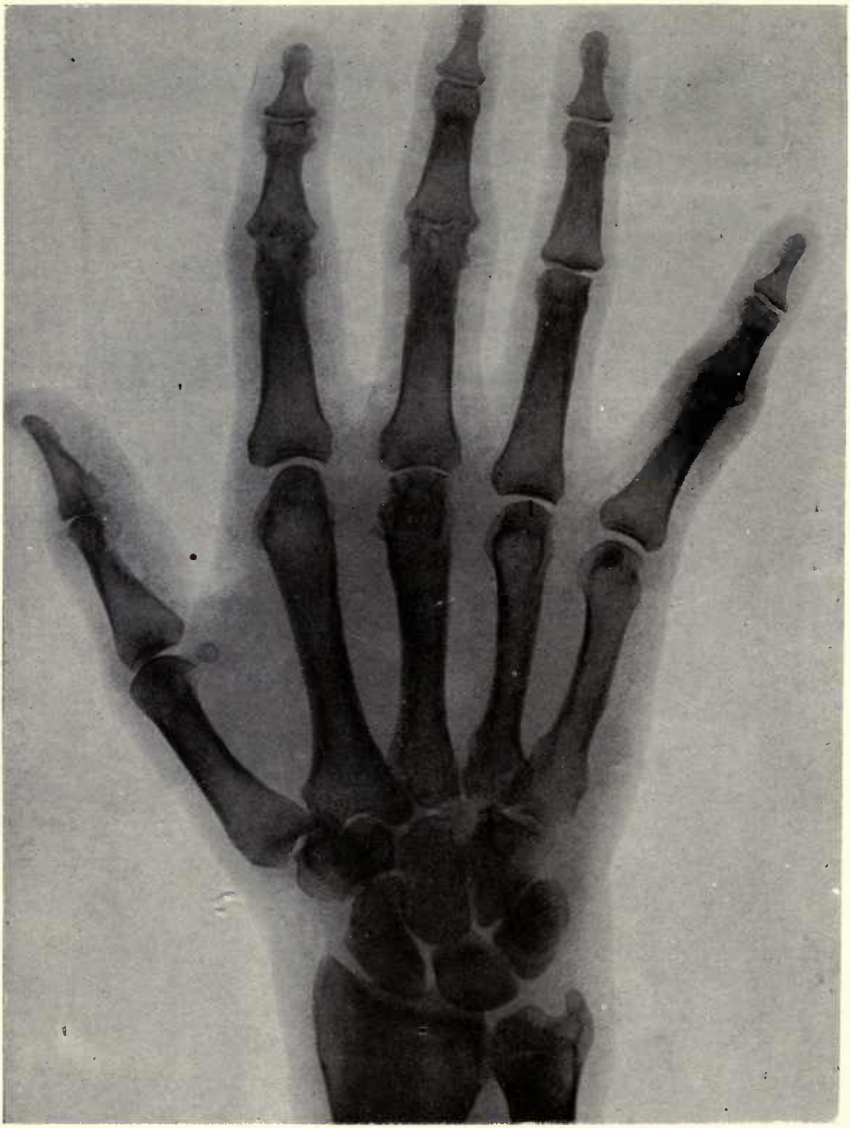


FIG. 10.

A Case of Recovered Rheumatoid Arthritis. Note the Formation of Small Osteo-arthritic Nodules.

FIG. 11.

Osteo-arthritis.—Secondary Changes supervening in Old Gouty Joints.

FIG. 12.

Secondary Osteo-arthritis.

FIG. 13.

Secondary Osteo-arthritis.

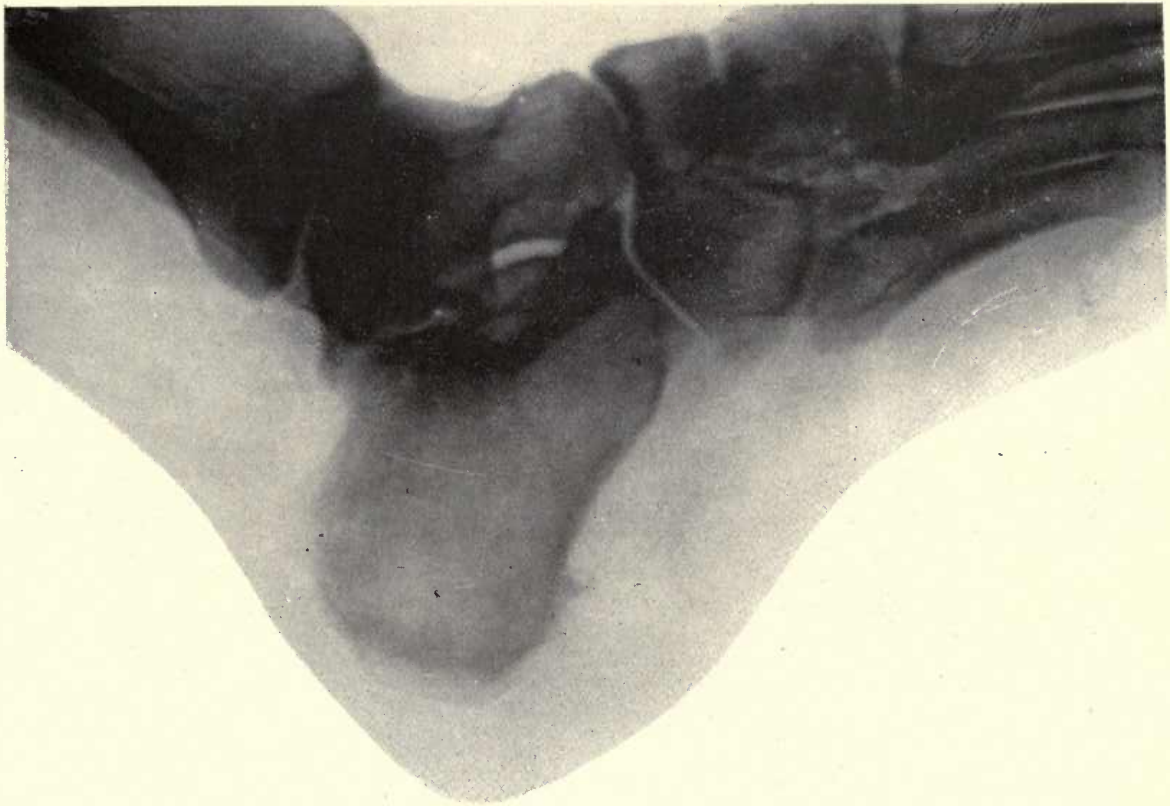


FIG. 14.

Gonorrheal Arthritis. Note the Spur from the Os Calcis.

FIG. 15.

Gonorrheal Arthritis.—Hand severely affected, but no Noticeable Alteration of Appearance of the Bones.

FIG. 16.

Gonorrheal Arthritis. Clinically the Hands simulated Rheumatoid Arthritis, but the Bones are shown unaffected.

FIG. 17.

Tubercular Arthritis. Note the Characteristic Fluffy Blurred Outlines of the Bones entering the Affected Joints.

FIG. 18.

Tubercular Arthritis of the Wrist.

TABLE B.

Disease.	Number of Consecutive Cases.	Positive.	Negative.
1. Gout (including "goutiness," and as defined at page 91)	243	157	86
2. Rheumatism (including convalescence from acute rheumatism and subacute rheumatism, but excluding the cases commonly called "chronic rheumatism," (*cf.* page 91)	92	59	33
3. Sciatica	171	80	91
4. Rheumatoid arthritis (as defined at page 92)	48	22	26
5. Osteo-arthritis (as defined at page 92) ..	65	25	40
6. Lumbago (gouty or rheumatic)	27	9	18
7. Gonorrheal arthritis	41	11	30
8. Syphilitic arthritis	2	0	2
9. Neuritis and neuralgia (other than sciatic) ..	43	21	22

The general conclusion arrived at is that in true gout and rheumatism only is there any noticeable family taint, and that in the other cases the incidence of a positive family history is about normal.

TABLE C.—COMPARATIVE FREQUENCY OF PREVIOUS ATTACKS OF ACUTE RHEUMATISM OR ACUTE GOUT.

Disease.	Number of Consecutive Cases.	Positive.	Negative.
1. Gout	243	90	153
2. Rheumatism	92	72	20
3. Rheumatoid arthritis	48	2	46
4. Gonorrheal	41	5	36
5. Syphilitic	2	0	2
6. Sciatica	171	16	155

The comparative frequency of a positive history in rheumatism is due, of course, largely to the system of classification adopted (*cf.* page 91). It will be noticed that in rheumatoid arthritis a history of previous acute rheumatism or gout is extremely rare. Even when a history of acute rheumatism is given, it will almost always be found on inquiry that the onset of rheumatoid arthritis, which is often quite acute, has been mistaken for rheumatic fever.

These figures would go to strengthen the belief that the relationship between rheumatoid arthritis and the "rheumatic" diseases is, at any rate, not very close. Meantime it is worthy of note that in two of the cases a sister of the patient also suffered

from rheumatoid arthritis, and that more than two-thirds of the cases consisted of young women.

In gonorrheal arthritis I had expected to find a general tendency to " arthritism " acting as a predisposing factor in the selection of the joints by the gonococcic poison, but analysis of the statistics does not confirm the theory. Here, again, also one has to question the statements of patients very closely, as the onset of gonorrheal arthritis is almost invariably referred to as " rheumatic fever."

Of the five positive cases, one had been liable to subacute rheumatic attacks since childhood, one really appeared to have had acute rheumatism with mitral disease, and the other three were perhaps doubtful.

In sciatica only about 10 per cent. gave a history of previous attacks of acute arthritis, and in the vast majority of cases these attacks appeared to be gouty.

Table D.—Inquiry as to the Relative Frequency of Right and Left Sciatica.

In 232 consecutive cases 122 were left side only, 86 were right side only, and 24 were double. About 13 per cent. were definitely traumatic. One case exhibited shingles along the course of the nerve.

Erythema Nodosum.—Five cases of this occurred in 335 consecutive cases of gout and rheumatism.

CHAPTER VIII.

HANMER.

What Rotorua is to the North Island Hanmer is to the South. While by no means the only hot springs in the South Island, those of Hanmer are the only ones of any magnitude at present easily accessible, and they have an especial importance in that they can be reached by train from the most populous centres of the south without, what is to many invalids often a serious drawback, the discomforts of a sea-passage.

Climate.—Situated on an elevated plateau 1,220 ft. above sea-level, rimmed round by high mountains, and shut off by the central mountainous backbone of the island from the moist west winds, Hanmer possesses in its climate a curative factor scarcely less valuable than its mineral waters. The air is comparatively dry, absolutely pure, and has just that touch of keenness in it which

exhilarates and lessens fatigue—in a word, is "bracing." The prevailing wind is from the north-west, a fine-weather wind, but often rising to a gale between the months of September and December. The wettest months of the year are August and September, whilst the autumn months, and particularly May and June, are generally fine. In the winter there are a very large number of bright and brilliantly sunny days, with keen frost at night.

Season.—The baths are open all the year round, but the "season" is from October to May. The winter, however, holds out many attractions to those who need bracing up, and are yet not too invalided to endure the keen frosty air.

Access.—The principal route, and the only one practicable for invalids, is by train from Christchurch to Culverden—a distance of sixty-nine miles, and thence twenty-tour miles by motor-car to Hanmer.

Accommodation.—In the Township of Hanmer Springs there are several good boardinghouses and one hotel about two miles and a half away, while for hospital patients there is the Government Sanatorium.

The mineral waters arise within the Sanatorium grounds from a number of springs which all appear to have a common origin. The temperature of these springs varies from about 100° to 118° F., and the hot water is accompanied by a fairly copious evolution of carburetted-hydrogen gas (methane) the excess of which is collected and utilized for lighting and cooking purposes at the Sanatorium, though none is now withdrawn from the bathing-pools.

In 1912, to augment the supply of water, bores were put down and a very copious flow at a temperature of 120° F. was obtained. The waters, according to an old analysis, were of a feeble sulphuretted-saline nature, but a recent examination shows ingredients which make the Hanmer waters almost unique among the known mineral waters of the world. They have been freely drunk for many years, chiefly in the treatment of arthirtic diseases and in dyspepsia. The more careful observation, however, which has been made possible of late by closer medical supervision, brought to light the fact that a considerable proportion of patients suffered, after drinking the waters, from intestinal disturbances, and a fresh analysis revealed the reason in the hitherto unsuspected presence of borax. The strength of the solution as a mineral water is hardly sufficient to exert much appreciable antiseptic action on the skin of the bather, but it is quite sufficient to make its presence sometimes unpleasantly manifest when taken internally, especially when large quantities of mineral water are ingested over a prolonged period.

Of the therapeutic effects of the salts of boric acid taken by the mouth in medicinal doses but little is known, and of the effects of a borated mineral water still less, as such waters are rare and, such as exist, contain but very little borate. Thus, the waters of Baden (Switzerland) contain traces of borates, but the amount is so small that, so far as I am aware, no clinical evidence of their effects has been recorded. In New Zealand the Puketitiri Spring (Napier) contains 4 grains of borax per gallon and the "Magnesia Spring" at Taupo 5 grains; but here again no clinical records of their action exist, except that the Taupo water has a popular reputation as a laxative, an effect hitherto, and erroneously, attributed to magnesia.

Borates have been used as a substitute for bromides in epilepsy, but their action is uncertain and apt to be attended by uncomfortable toxic symptoms. G. Seng* used boracic acid and borax for reducing weight, giving small doses, gradually increased to 15 gr. or 20 gr. a day, but found the drug not well borne. Boracic acid has also been used in diabetes, apparently with some success, and its action as a urinary antiseptic is, of course, familiar. The thought naturally suggests itself of the possible use of a borated mineral water as an intestinal antiseptic. For intestinal lavage by the Plombières method the water should be of service, but the value of antiseptics given by the mouth is still dubious clinically, and the results of the specific action of boric acid obtained experimentally on the organisms of the B. coli group are somewhat contradictory. Thus, Klein says that 0·5-per-cent. solutions inhibit the growth of B. coli communis and of B. Gaertner; while Bernstein found the growth of saprophytic organisms inhibited, but that of the coliform group much less so.

On the other hand the toxic effects of boric acid are well known. Cases of severe gastro-intestinal disturbances in infants as a result of the too free and injudicious use of borax and honey have frequently been recorded,† and the use of boracic acid as a food-preservative has been strictly regulated by Health Departments throughout the world.‡ Chevalier§ pointed out the danger of the drug when elimination is defective—*e.g.*, in renal insufficiency. On the whole, then, it would seem that it were wiser not to

* Treatment: Aug., 1903, quoting Ther. d. Gegerno, April, 1903.

† *Cf.* McNeill, B.M.J., July 20, 1912.

‡ Boric acid has an irritative influence on the alimentary tract, and may produce headache, malaise, abdominal discomfort, vomiting, diarrhœa, skin-eruptions, and defective assimilation of food. (Report of Dr. Hamill, L.G.B. Food Dept., 1910.) The Local Government Board circular, 1906, lays down that boric acid in a solution of over 40 gr. per gallon is injurious to infants.

§ Revue Franç. de Med. et de Chir., Jan., 1905.

administer this water by the mouth, except perhaps in small doses and under close medical supervision.

The waters also contain sodium-sulphide* and appreciable quantities of lithium-chloride,† which would make them valuable in gouty conditions were it not for the disturbing element of boron. The amount of sodium-chloride present is too small to be likely to have any pronounced pharmacological properties, though here again one has to speak with caution in comparing a natural with an artificial solution of salts. Certain it is that universal clinical experience has attributed to quite weak saline waters a stimulating effect on the secretory activity of the stomach.

Analysis (1912).

Ammonium-chloride	1·57
Lithium-chloride	0·67
Potassium-chloride	0·25
Sodium-chloride	75·37
Sodium-silicate	5·52
Sodium-borate	25·10
Sodium-sulphide	2·07
Sodium-bicarbonate	3·88
Calcium-bicarbonate	2·28
Ferrous bicarbonate	0·04
Carbon-dioxide free	7·60
	124·35

The Baths.—It will be seen that it is to its baths and to its climatic influences rather than to its potable waters that Hanmer looks for its reputation as a health resort. There are several bath-buildings dotted about the spa gardens, their positions having been determined originally either by the site of a spring or by the contour of the ground enabling the waters to be led into them by gravitation.

Of the former class are the "swimming-pools"—two oval concrete baths some 30 ft. long and 4½ ft. deep—open to the sky, but

* For the action of sulphides, see page 74.

† See, however, page 105, on the conflicting views held as to the value of lithium in gout. Luff (Hutchinson and Collier's "Index of Treatment") says, "The chief objection to the lithium-salts is their greater toxicity and depressing action on the heart as compared with potassium-salts. They consequently have to be given in such small doses that it is doubtful whether they possess any remedial effect." The possible effects, however, of ionization, when lithium-salts occur in small quantities in mineral water, must not be overlooked. The question is still *sub judice*.

protected by awnings in the summer from the direct rays of the sun. These baths were formerly kept at a temperature of from 90° to 97° F., and were consequently more suitable for recreative than for therapeutic purposes. The greatly increased amount of mineral water now available, however, has enabled the installation of undercurrent douches, which have not only greatly increased the temperature of the baths, but have immeasurably increased their therapeutic potentialities. In addition, the gas, which formerly was withdrawn from the pools, is now allowed to bubble freely through the water, thereby somewhat increasing its stimulating action on the skin, and, on account of the lower indifferent temperature of gases as compared with that of water, increasing the apparent temperature of the bath.*

The private baths, some twenty-two in number, are of the ordinary shallow immersion type. They are fitted with hot undercurrent douches and cold showers, are roomy and comfortable, and the temperature of the water can, of course, be varied to suit the bather. Special baths and towels are reserved for patients suffering from diseases of the skin.

Swimming-bath.—A very fine cold fresh-water swimming-bath has now been converted into a tepid mineral-water bath. Apart from purposes of recreation, a warm swimming-bath affords invaluable exercise to many patients too crippled to walk but not too crippled to swim.

Massage, Electrical and Special Treatments.—A system of douche massage, a combination of the familiar Aix and Vichy types closely resembling that in use at Rotorua, has recently been installed, together with circular needle-baths, hot-vapour cabinets, packs, &c. In the dry-massage department treatment is given under medical prescription only, and may be combined with the usual faradic and galvanic applications or with electric baths.

Inhalation.—The present arrangements for inhaling the vapours of the waters are decidely primitive, and consist merely of pipes leading from a reservoir over a hot spring into the open air. Patients seated above the reservoir can thus inhale the steam, which consists only of simple hot-water vapour and a slight admixture of the gases, the salts of the water, of course, not arising with the steam. Owing to the minute subdivision of the water, however, this vapour penetrates far into the bronchial tubes, and is not arrested in the upper passages as it would be in an ordinary spray. It thus exercises a bland sedative action on the mucous membranes, and tends to liquefy the bronchial secretions. Neither gases nor water have yet been examined for radio-activity.

* *Cf.* page 14.

Cases Suitable for Treatment.—The baths are indicated in the usual chronic " arthritic " diseases, and in the local manifestations of these diseases, such as sciatica, lumbago, and certain forms of neuralgia and mild neuritis. For cases specially requiring douche massage, electrical treatment, and so forth, the reader is referred to the chapter dealing with these matters under the head of " Rotorua," with the proviso that the equipment at Hanmer is much less complete, and serious cases of disease of the central nervous system requiring special exercises, &c., should, at present at any rate, be sent preferably to Rotorua. Patients suffering from true rheumatoid arthritis are likely to receive considerable benefit from the combination of the bracing climate and balneological treatment. The same remark applies to many cases of anæmia, nervous exhaustion, and insomnia.

Certain digestive troubles, such, for instance, as atonic dyspepsia and constipation, will do well with a combination of massage douche, electrical treatment, and possibly small doses of the waters by the mouth. Here, again, while the bracing climate and the treatment assist the cure and stimulate the appetite, it must be remembered that the increased appetite may have to be restrained at first in the dyspeptic, while the diet, of course, must be carefully regulated in quality. Certain skin-diseases, notably chronic eczema and mild cases of psoriasis, are usually benefited by prolonged immersion baths. It is possible that the mild antiseptic action of the borax may be of value in such cases.

Convalescents from acute diseases will find the pure bracing upland air markedly invigorating, but must be careful in the matter of bathing. Stiff joints and muscles, after injury or operation, will be rendered more supple by a course of baths, especially douche massage. In regard to chronic lead-poisoning and the secondary changes resulting therefrom, a good deal of benefit is likely to result from treatment, but this, I take it, is due to spa treatment as such rather than to any specific action of the waters.

As already noted, borax would appear to possess some specific action in the reduction of weight in obseity and in diabetes, but the toxic effects of the salt when pushed to the necessary degree would appear to make the treatment somewhat risky.

Contra-indications.—There is no need to detail again the cases which are unsuitable for treatment, as the question has already been considered fully in previous pages, but the position may be summarized by saying that patients in an acute stage of any disease should not be sent—spa treatment is for chronic and subacute stages only.

Hill-climbing and other Forms of Exercise for Therapeutic Purposes.—A large proportion of those who resort to Hanmer come for rest and change. In many cases, during either part or the

whole of the course, rest is absolutely essential, and serves to counterbalance the fatigue induced by a course of hot baths; but frequently, and indeed in the majority of cases, a certain amount of exercise is highly beneficial. For those persons, otherwise in good health, who are merely suffering from the effects of a too sedentary life, the exercise may take the form of walks, of ordinary out-door sports, or of mountain-climbing, care being taken, of course, not to attempt too much at first; but, for those suffering from actual organic disease, exercise, while equally beneficial, must be much more carefully graduated. Many cases of heart-disease, of anæmia, of obesity, and of constipation will benefit by a judicious course of hill-climbing, such as is afforded, for instance, by the slopes of Conical Hill, but all patients with organic disease should avoid this method except under the strictest medical supervision.

The Government Sanatorium. — The Sanatorium, of eighteen beds, is intended primarily for patients of the hospital class, and is in charge of a Resident Medical Officer, to whom applications for admission, supported by a medical certificate as to fitness for mineral-water treatment, must be forwarded, and by whom patients are also examined before admission.

CHAPTER IX.

TE AROHA.

This is a pretty little watering-place nestling at the foot of Te Aroha Mountain, a picturesque and forest-clad peak standing out boldly at an angle of the Paeroa Range. In front, over the winding Waihou River, it overlooks the broad valleys of the Thames and Waikato.

The springs, over twenty in number, but not very abundant in outflow, are scattered over an extensive public garden on the lowermost slopes of the mountain, and a number of baths are dotted about the grounds, their situation generally determined by the outcrop of the principal springs. While Rotorua is essentially a bathing-resort, Te Aroha is especially a place for drinking the waters.

Around several of the springs the ground is discoloured by a deposit of oxide of iron,* through which carbonic-acid gas finds its way by numerous small vents.

* Ferrous carbonate, held in solution in the presence of CO_2, becomes oxidized by the atmosphere to the insoluble oxide as the CO_2 is lost.

Nature of the Waters.—All the waters, with the exception of one or two minor springs, conform to one main type—the *alkaline*—closely resembling the waters of Vichy (France), but containing a very much larger proportion of sodium-bicarbonate, and ranking as one of the strongest, probably the actual strongest, alkaline thermal waters of the world in therapeutic use. As in the Vichy waters, there is also present a small proportion of sodium-chloride, and a still smaller quantity of ferrous bicarbonate, with a fair amount of free carbonic acid. In one of the springs there is also a trace of lithium, as in the Source Sainte Marie, near Vichy, but it is hardly probable that this has any appreciable therapeutic effects.*

The main springs are very hot (up to 135° F.), but some of the smaller are nearly or quite cold. Amongst the latter is the Magnesia Spring, which has a sweetish taste, and contains magnesium and calcium bicarbonates, and the Iron Spring, which is feebly mineralized, but contains 1·2 gr. of ferrous bicarbonate per gallon.

Pharmacological Action of the Waters.—As we have seen, the principal ingredients are sodium-bicarbonate and sodium-chloride, and the most conflicting views are held about the action of both these salts. For all practical purposes, however, this may be looked upon as a simple alkaline water, as the amount of chloride is so small.

It is generally acknowledged that the additional presence of sodium-chloride renders alkaline waters less "lowering." This would appear to be due to the stimulating action of the chloride on the secretory activity of the gastric mucous membrane, so that a muriated alkaline water is preferable to a simple alkaline in cases of organic gastric disorder when associated with diminished secretion and subacidity of the gastric juice—*e.g.*, chronic catarrhal cases.† In direct contradiction to Sir W. Roberts's opinion, some attribute to sodium-chloride inhibitory action on the deposition of uric acid.‡

A pure bicarbonate water is said to be more likely to precipitate an attack of gout than is a muriated alkaline water. Certain it is that Te Aroha water must be used with discretion in gouty

* There would appear to be a growing disbelief in the value of lithium in gout. Some authorities aver not only that it is useless, but that it irritates the stomach and acts as a general depressant. (*Cf.* Murrell, Clin. Journal, May 19, 1909; and Fenner, *Lancet*, Dec. 19, 1908.) On the other hand, there can be little doubt that, introduced electrolytically through the skin, lithium may have considerable value, and it is highly recommended by Leduc and others. With lithium-chloride at the anode, lithium is driven in, and the uric-acid ion may be found in the electrode. In an ionized mineral water it is possible, of course, that the lithium ions may act with more energy than their molecular concentration would suggest, so that even a very weak lithium water may have some therapeutic value.

† Weber (Balneotherapy), quoting Bickel's experiments.

‡ Weber (*ibid.*), quoting Felix's experiments.

cases, and it is quite common to see acute attacks precipitated by the incautious use of the waters, especially amongst the self-dosers, whose idea is " the more the better."

The views held as to the action of sodium-bicarbonate are extremely hard to reconcile. The experiments of Pawlow* would indicate that the alkali has an inhibitory rather than a stimulating effect on gastric and pancreatic secretion, and acts beneficially by giving a rest to the glandular apparatus during the period when secretion is not required. Linossier,† however, maintains that sodium-bicarbonate stimulates the secretion of HCl. He says the alkali acts in two ways—(1) The immediate chemical action neutralizes free acid; (2) further action stimulates the secretion of HCl., but not of pepsin, so that the final result is an increase of HCl.

To increase gastric acidity the alkali should be given before meals; to neutralize excessive acidity large doses should be given two hours after food, so that the food leaves the stomach before the drug causes a further stimulation of the hydrochloric acid. From this it is obvious that the motor activity of the stomach must largely determine whether the soda acts as an acidifier or an antacid.

In an earlier paper‡ the same observer advocates, in hypo-acidity, small doses 15 minutes before a meal, or large doses an hour before. Large doses cause a feeling of satiety, which is gradually followed by increased desire for food, the HCl. being first neutralized and then a greater flow being stimulated. In hyper-acidity he gives small doses every half-hour during digestion, beginning before the time that the pain comes on and continuing till digestion is finished. Long experience in the use of Te Aroha water has inclined me to endorse these views, but the practical difficulty arises that patients do not allow a sufficient time to elapse between their meals to carry out this line of treatment to its logical conclusion.

In gouty§ cases the plan I have usually adopted is to give 10 oz. of the water after a bath, and therefore presumably on an empty stomach, once a day for three or four days; if no considerable exacerbation of symptoms occur, to give then a second similar dose, generally after a second bath; finally, after another week or so, to give a third dose per diem on an empty stomach, preferably before breakfast.

* Weber (Balneotherapy), quoting Felix's experiments.

† Ann. de l'Acad. de Méd., Paris, April 14, 1908.

‡ " Journal des Praticiens," 1895.

§ As already mentioned, some physicians consider sodium salts contra-indicated in gout. Personally, I have grown more and more averse to giving Te Aroha water internally in this disease.

The principal sources for drinking are the Octagon Spring (No, 8), the "Pump Spring" (No. 15), the "Magnesia Spring" (No. 21), and Spring No. 22. Springs Nos. 8 and 15 are practically identical in chemical composition, though No. 15 is considerably the hotter, and popular opinion attributes to them different therapeutic properties. They are both alkaline waters of the type predominating at Te Aroha, and these are the springs referred to when the term "Te Aroha water" is used.

Indications.—Chronic gastric catarrh with hypo-acidity, under certain conditions (*vide supra*) and in fairly sthenic cases; hyper-acidity, when used according to certain directions (*vide supra*); chronic catarrh of the respiratory organs; gout; glycosuria.

The similar waters of Vichy have a special reputation in the treatment of biliary calculi,* but modern views of the pathology of this condition would tend to make one look rather to surgical interference than to mineral-water treatment for its relief. A course of mineral water, however, *after* operation for cholelithiasis is free from objection, and is, indeed, strongly recommended by some surgeons.

The strongly alkaline water may also be used in certain urinary troubles where an alkali is indicated. I have several times seen uric-acid stones passed during a course of these waters, but never a stone of any size, and have always hesitated to advise a course of the water in renal calculus.

Where stones have been passed they have generally been multiple small rounded uric masses about $\frac{1}{16}$ in. in diameter, seldom larger, not facetted, and probably formed in the bladder. Larger so-called uric-acid stones definitely located in the kidney are generally of mixed constitution, and the solvent action on them of the alkalies is more than doubtful.†

* It is probable that the beneficial effects of mineral waters in some cases of cholecystitis are due to purely mechanical causes, as appears to be the case in olive-oil treatment. Hypersecretion is set up, which mechanically sweeps out organisms and toxins.

† Benjamin Moore ("The Chemical Composition and Mode of Formation of Renal Calculi," B.M.J., April 1, 1911), making a quantitative analysis of twenty-four stones, found in twenty-one cases from the kidney and ureter, and one from the prostate, an enormous preponderance of calcium oxalate and phosphate, and a very small percentage of uric acid, and that largely in the form of the insoluble calcium-urate. Two stones taken from the bladder consisted of almost pure uric acid. As the solubility of calcium-oxalate and calcium-phosphate is enormously decreased by increased alkalinity, it is obvious that in twenty-two cases out of the twenty-four—that is, in all the kidney cases—harm would have been done by giving an alkaline mineral water. Indeed, it would appear probable that it is to their solvent action on bladder-stones, which may consist of almost pure uric acid, that the reputation of alkaline mineral waters in urinary cases rests.

The uses of the waters in diabetes must be guarded by certain well-defined reservations. Young, thin, asthenic subjects, in fact grave cases generally, should not be sent to Te Aroha; while plethoric middle-aged gouty people—cases of gouty glycosuria—may do very well indeed. It is well to remember, however, that little facility exists for special dieting, and that unless a patient is prepared to take a furnished house he may have almost insuperable difficulties in obtaining a proper dietary.

The weak *magnesia water* (Spring No. 21) is a pleasant corrective in acid dyspepsia; indeed, the somewhat similar spring at Paeroa had, I am told, in the old days the reputation among the gold-miners of the district as a Sunday morning drink after a "Saturday night burst." Several "magnesia springs" of almost identical composition arise in adjacent private property.

The *iron-water* (No. 20) is indicated in some anæmic dyspeptics, Spring No. 22 is a similar but weaker chalybeate, but tepid instead of cold.

The Baths.—There are a number of excellent private and public immersion baths, but the accessories of douches, massage, electric treatment, &c., are almost non-existent at present, and this is a very serious handicap to the usefulness of the spa. There has always been a preference among the invalids for the public immersion baths, as these are built directly over the springs, and the hot water and carbonic-acid gas bubble through their floors. In view of the action of carbonic acid on the skin, and especially fresh carbonic acid, this preference is justified, though the amount of the gas present is but small. No. 2 bath, which is generally kept at a temperature of from 102° F. to 104° F., is the favourite.

The "skin-disease bath" is a small private bath supplied partly from Spring No. 16, a tepid to cool alkaline water containing a certain amount of sulphuretted hydrogen. It has probably gained its reputation from the deep popular belief in sulphur as a skin-medicament.

The Cadman Baths are a suite of private immersion baths supplied principally from Springs Nos. 13, 14, and 15.

Indications.—The baths may be used with advantage in conjunction with drinking the waters in all arthritic cases. For a general account of the action of mineral-water baths, the reader is referred to pages 16 to 25.

Apart from this general action, the water would appear to have a special effect in certain skin-diseases. Thus, in cases of seborrhœa of the scalp, and in those very frequent cases in which psoriasis on the body merges imperceptibly into seborrhœa on the scalp, the alkali forms a soap with the seborrhœic material, and is of material assistance in removing crusts and scales.

Analyses of the Waters, in Grains per Gallon.

	Springs.								
	1.	2.	4.	6.	8 (1904).	9.	10.	11.	12.
Sodium-chloride ..	60·25	60·45	34·24	66·23	59·10	41·29	35·24	34·69	41·66
Sodium-bicarbonate	461·56	426·29	246·49	499·75	648·00	301·17	276·19	261·44	300·97
Sodium-sulphate ..	38·32	32·67	19·16	35·14	39·2	22·16	19·19	20·12	22·96
Potassium-chloride ..	1·72	1·90	..	..	10·0	..	..	..	..
Calcium-bicarbonate	10·77	7·12	4·62	7·12	8·9	4·94	4·67	5·11	5·12
Magnesium-bicarbonate	6·86	4·21	2·14	2·99	2·5	2·61	2·31	2·56	2·99
Ferrous bicarbonate	..	..	..	..	..	..	..	..	..
Lithium-chloride ..	..	..	..	..	..	..	..	..	..
Silica	7·56	7·12	5·17	7·14	8·0	6·44	6·0	6·11	7·11
Total solids ..	586·96	539·76	311·82	618·37	775·70	378·61	343·60	330·03	380·81
Free carbonic acid ..	..	..	..	..	55·0	..	..	..	..
Temperature (Fahr.)	135°	..	106°	..	..	..	..	115°	..

	Springs.							
	13.	14.	15 (1904).	17.	18.	20 (1904).	21 (1904).	22 (1903).
Sodium-chloride ..	40·67	42·61	59·5	2·71	16·12	1·9	23·9	26·57
Sodium-bicarbonate ..	301·64	321·64	657·4	9·36	131·72	3·3	258·1	179·81
Sodium-sulphate ..	21·86	23·16	40·1	3·92	8·16	9·1	9·3	18·19
Potassium-chloride ..	..	..	11·0	..	..	1·3	4·1	1·08
Calcium-bicarbonate ..	6·11	7·14	6·8	0·64	1·97	8·9	31·5	31·82
Magnesium-bicarbonate	3·13	3·49	2·5	0·27	1·01	11·9	13·3	11·24
Ferrous bicarbonate ..	..	..	..	..	..	1·2	0·7	0·12
Lithium-chloride ..	..	..	..	..	..	..	..	traces
Silica	6·86	6·66	7·0	4·21	13·14	4·5	13·5	3·92
Total solids ..	380·27	404·70	784·3	21·11	172·12	42·1	354·4	272·75
Free carbonic acid ..	..	..	37·4	..	..	60·4	103·4	71
Temperature (Fahr.) ..	135°	135°	135°	..	..	cold	cold	tepid

*Radio-activity of Waters.**

	Activity: Radium, Grammes $\times 10^{-12}$ per c.c.
No. 2 Spring ..	0·026
No. 6 „ ..	0·015
No. 8 „ ..	0.010
No. 15 „ ..	0·031
No. 20 „ ..	0·056
No. 22 „ ..	0·130†

*Radium-content of Waters.**

	Activity: Radium, Grammes $\times 10^{-12}$ per c.c.
No. 2 Spring ..	0·0009
No. 6 „ ..	0·0002
No. 8 „ ..	0·0010
No. 15 „ ..	0·0012
No. 29 „ ..	0·0005

* Maclaurin and Wright, Annual Report, Dominion Lab., 1911.
† Roughly only 0·23 Maché units.

CHAPTER X.

THE MINERAL WATERS OF NEW ZEALAND: A GENERAL REVIEW.

The North Island of New Zealand is a land peculiarly rich in mineral springs, and more particularly in thermal springs of high temperature. These latter are especially numerous in the volcanic region stretching from the central active volcanoes through Taupo, Wairakei, Waiotapu, and Rotorua to the Bay of Plenty, and, indeed, out to sea to White Island. But numerous scattered hot springs are found as far south as the Wellington Province and as far north as Ohaeawai, towards the Bay of Islands.

The different classes of mineral water have a rough general plan of geographical distribution, so that the probable nature of a spring may, to a certain extent, be inferred by its position on the map, though this is a rule with many exceptions, and the point must not be pressed too far. Thus, in the central pumice plateau, from Mount Ruapehu in the south to Rotorua in the north, the vast majority of the springs are very hot, sulphuretted, siliceous, and weakly mineralized; the sulphuric-acid springs are found in the same district, and in certain islands in the Bay of Plenty; along the east coast, from East Cape to Cape Palliser, muriated waters of high specific gravity, and containing iodides, predominate; along the coast, from the Bay of Plenty northwards, weak saline waters are found; in the lower Waikato Valley are chiefly simple thermal waters; in the Thames Valley alkaline bicarbonated waters, both hot and cold; while in the limestone regions of the northern peninsula are waters, cold or slightly warm, rich in carbonic-acid gas.

The South Island is comparatively poor in thermal springs, and these are for the most part "indifferent" or feebly saline waters of low specific gravity.

General Classification.—At the outset one is met with considerable difficulties in the attempt to classify mineral waters. Whatever system of classification be adopted is open to serious objections. Until recently waters have generally been classified according to their apparent chemical composition, or perhaps, one might say, according to their gross chemical composition. This method rests on the assumption that certain ingredients which bulk most largely in the analysis, or which from their therapeutic activity appear of predominating importance, determine the general character of the water in so far as the physician is concerned. Recent research, however, has made us

accept this assumption only with grave reservations, and it is realized that other important factors have to be considered.

Bearing in mind, however, the imperfect nature of our knowledge of these new factors, it would seem unsatisfactory and misleading at present to express analyses in terms of ions or electrical conductivity or radio-activity, and ordinary chemical constitution has alone been considered here.* The nomenclature adopted, too, while manifestly at best a compromise,† is that most familiar to English readers, and, at any rate, affords a serviceable classification for medical purposes.

For the purpose of comparison, a well-known example of a European mineral water is given with each class, except, of course, in those rare instances in which a New Zealand water has no corresponding European prototype.

Simple Thermal Waters.

These constitute a somewhat indefinite group of waters characterized by weak mineralization. Obviously, it tends to shade off at one extremity into any one of the other groups, so that a particular water may be classified by one authority as "simple thermal," by another as "saline," and so on. Such waters, when used as baths, owe their therapeutic value very largely to the hot water as such,‡ except perhaps in the case of markedly radio-active waters, and therefore largely to the skill with which they are used.

As a rule the springs yield an abundant supply, and it is a notable fact that, in European spas supplied by simple thermal waters, the development of systems of douching, and, indeed, of hydro-therapeutics generally, has reached a high pitch of perfec-

* The following classified list of waters is based almost entirely on the analyses recorded in the reports of the Dominion Museum and Laboratory, published by the Mines Department, between the years 1874 and 1912, and of these a large proportion of the more important have recently been made by Dr. Maclaurin, Dominion Analyst. On account of the space which would be required to give the full detailed analysis of each specimen, only the essential and characteristic ingredients are given here, together with the total grains per gallon of solid constituents. In all cases, however, in which the analyses have been taken from the above reports, the year is also given to facilitate reference should fuller details be required. For further information on this subject the reader is referred to the paper by Mr. W. Skey in the "Transactions of the New Zealand Institute," 1877, to several published pamphlets by Mr. J. A. Pond, and to the article by the late Sir James Hector in the Official Year-book, 1893. The names Skey, Pond, and Hector at the head of an analysis have reference solely to the above-mentioned papers.

† Dr. Peale (Cohen's System of Phys. Ther.) devised a more accurately descriptive system, but such uncouth strings of adjectives as "alumino-chalybeate-sulphated saline" seem too cumbersome for everyday use.

‡ *Cf.* The physiological effects of plain hot water and of hot mineral water, page 15 *et seq.*

tion. Such waters, too, are more fully ionized, and, as a rule, more radio-active than those of high specific gravity. In addition to their use as baths, they are used internally for flushing the system.

Little has been done in this country in the way of developing these springs, but immersion baths of a more or less primitive nature exist at Okoroire, Matamata, and Waingaro.

EUROPE.

Gastein.

Total solids	21·0*
Temperature	121° F.

NEW ZEALAND.

Waingaro (1904).

Sodium-chloride	6·43
Silica	7·80
Total solids	22·66
Temperature	130° F.

Matamata (1904).

Sodium-bicarbonate	28·10
Total solids	46·66
Temperature	106° F.

Okoroire.

Sodium-chloride	17·18
Silica and silicates	9·70
Total solids	42·34
Temperature	113° F.

Haupiri (1901).

Sodium-silicate	7·3
Total solids	19·3

Whangape, Waikato (1909).

Sodium-chloride	17·25
Total solids	35·50
Temperature	150° to 200° F.

Te Teko (1909).

Sodium-bicarbonate	14·2
Total solids	26·2
Temperature	150° F.

* Here, and throughout this book, the figures are given in grains per gallon unless definitely stated otherwise.

Roadman's Bath, Waiotapu (1909).

Sodium-chloride	40·9
Total solids	69·7
Temperature (at source)	212° F.

Taheke, Rotoiti (1908).

Silica	15·0
Total solids	27·5
Temperature	212° F.

Maruia (1903).

Total solids	36·5
Temperature	140° F.

Mount Egmont (1883).

Calcium-carbonate	6·72
Total solids	26·23

Hurunui (1885).

(Complete analysis not available.)

Franz Josef (1901).

Total solids	56·21

(Principally sodium chloride and carbonate.)

Lake Sumner. (Skey.)

Total solids	18·56
Temperature	93° F.

Miranda, Thames. (J. A. Pond.)

Sodium-chloride	15·17
Total solids	31·27
Temperature	134° F.

Katikati (1904). (*Vide* also "Muriated Waters.")

Sodium-chloride	119·54
Total solids	137·26

Muriated Waters.

The principal ingredient of these waters is common salt. In this country, in the majority of instances, they are hot, and are used both for baths and for drinking purposes. In the former case they exert a stimulating effect on the nerve-endings in the

skin; while, taken internally, they stimulate the mucous membrane of the gastro-intestinal tract, and have a diuretic and sometimes a laxative effect.

Hitherto no use has been made in New Zealand of the concentrated *mutterlauge* so much used on the Continent of Europe, though indeed some of the waters are so strong naturally as to need little concentration to rival these "mother-liquors" in strength.

Taken as a whole they constitute an important and numerous group, and are distinguished by their geographical distribution and by certain chemical peculiarities. Thus the great majority arise near the coast, especially the east coast of the North Island. A great number of the waters, too, contain very considerable quantities of calcium-chloride and of sodium-iodide, so that the muriated waters fall naturally into three main groups—those containing a great preponderance of sodium-chloride, those in which calcium-chloride is present in so great a quantity as to rival or even surpass the sodium-chloride in importance, and those in which sodium-iodide is present in noticeable quantities. The great majority of the second class, however, belong also to the third. A few springs containing magnesium-chloride have been included as a fourth group.

Baths have been erected at Helensville, Morere, Te Puia, and Tarawera, but, beyond simple immersion baths, no facilities for balneological treatment exist.

Class I.—Sodic Muriated Waters.

EUROPE.

Wiesbaden.

Sodium-chloride	420
Temperature	100° to 156° F.

NEW ZEALAND.

Helensville (1889, 1903). (*Vide* also "Iodide Waters.")

Sodium-chloride	114·46
Total solids	134·68
Temperature	115° to 146° F.

Hokianga (1878). (Pond.)

Sodium-chloride	2797·4
Total solids	2937·5

Hokianga, Rotokakahi (1905).

Sodium-chloride	1350·0
Total solids	1543·0

Patangata (1902). (*Vide* also "Chalybeate Waters" and "Iodide Waters.")

Sodium-chloride	152·2
Total solids	176·4

Waimate (1883). (*Vide* also "Iodide Waters.")

Total solids	586·63 to 834·32

Raukawa, Hawke's Bay (1912). (*Vide* also "Iodide Waters.")

Sodium-chloride	446·1
Total solids	567·0

Papaite, Wanganui (1886).

Sodium-chloride	313·41
Total solids	348·54

Pipiriki, Wanganui (1888).

Spring on left bank—Sodium-chloride ..	121·88
Total solids	130·61
Spring on right bank—Sodium-chloride ..	231·64
Total solids	244·03

Mokau, Motukarama (1888). (*Vide* also "Iodide Waters.")

Total solids	844·0

(Incomplete analysis.)

Kotuku, Greymouth (1904). (*Vide* also "Chalybeate Waters.")

Sodium-chloride	162·20
Total solids	201·25

Katikati (1904).

Sodium-chloride	119·54
Total solids	137·26

McLean's, Napier. (Skey.)

Total solids	444·7

Mahurangi, Auckland. (Skey.)

Total solids	141·0

Mercury Bay (1908).

Sodium-chloride	200·8
Total solids	259·4

Class II.—Calcic-Sodic Muriated Waters.

The nearest European prototype to such a class of waters is Kreuznach.

Calcium-chloride	140·0
Sodium-chloride	700·0

When this and similar waters are evaporated to a *mutterlauge*, as is so frequently done, thereby precipitating some of the sodium-chloride, and leaving a concentrated solution of the chlorides of magnesium and calcium with some iodides, a striking resemblance is found to certain of the New Zealand waters.

NEW ZEALAND.

Kawhia (1903). (*Vide* also "Iodide Waters.")

Calcium-chloride	585·51
Sodium-chloride	424·55
Total solids	1040·76

Mataroa (1903). (*Vide* also "Iodide Waters.")

Calcium-chloride	128·21
Sodium-chloride	1625·25
Magnesium-chloride	85·70
Total solids	1843·43

Okain's Bay (1904). (*Vide* also "Chalybeate Waters.")

This is an artificial spring of cold water obtained from a bore sunk into the recent soil of a rapidly silting-up bay, and is remarkable for the unusually large amount of iron in solution.

Calcium-chloride	468·5
Sodium-chloride	295·5
Magnesium-chloride	264·8
Ferrous bicarbonate	26·7
Total solids	1128·9

Totoro, Mokau River (1905). (*Vide* also "Iodide Waters.")

Calcium-chloride	681·0
Sodium-chloride	784·0
Total solids	1496·0

Morere (1903, 1905). (*Vide* also "Iodide Waters.")

Calcium-chloride	594·78
Sodium-chloride	1249·67
Total solids	1899·60
Temperature	120° F.

Te Puia (1906). (*Vide* also "Iodide Waters.")

Calcium-chloride	153·40
Sodium-chloride	807·75
Total solids	978·69
Temperature	150° F.

Kopuowhara, Mahia (1885). (*Vide* also "Iodide Waters.")

Calcium-chloride	177·82
Sodium-chloride	1027·66
Total solids	1241·65

Great Barrier Island (1904).

Calcium-chloride	103·75
Sodium-chloride	791·50
Total solids	985·23
Temperature	180° F.

Pahaua, Wellington (Skey; also 1878). (*Vide* also "Iodide Waters.")

Calcium-chloride	120·88
Sodium-chloride	1303·32
Total solids	1474·09

Kotuku, Greymouth (borehole), (1904).

Calcium chloride, sulphate, and bicarbonate	458·8
Sodium-chloride	5134·0
Total solids	5936·8

Wallingford, Wellington (Skey). (*Vide* also "Iodide Waters.")

Total solids	826·0

Mercury Bay (1908).

Calcium-chloride	21·6
Calcium-bicarbonate	22·5
Sodium-chloride	200·8
Total solids	259·4

Class III.—Iodide Muriated Waters.

Iodine is found in these waters combined usually with sodium or magnesium; in addition there is generally present a certain and varying amount of free iodine. The amount of iodide present is seldom more than about 2·5 grains per gallon, but even this small quantity exceeds the amount present in most similar European waters, one of the richest of which (Heilbrun, Bavaria) is given here for comparison.

The therapeutic value of such minute quantities of iodide has been much questioned, though Neisser* has, on the other hand, pointed out the potent effect on human metabolism of minute quantities of iodine in thyroid extract. There remains the possibility, however, that the essentially active factor in these waters is not the iodide but the *free nascent iodine*, which is almost always present. The pungent smell of this mineral may generally be detected for some distance round the source of an iodide spring, and where the thermal water is broken up by a fall into a spray or douche, under which circumstances free iodine seems to be liberated, the odour is unmistakably strong. It is conceivable that, apart from the iodine that is taken into the system when the water is drunk, quite an appreciable amount, and that in a highly active condition, may be inhaled with the water vapour and spray by the bather. The possible effects of ionization also must not be overlooked.

EUROPE.

Heilbrun (Bavaria).

Sodium-chloride	343·0
Sodium-bicarbonate	63·0
Sodium-bromide	3·5
Sodium-iodide	2·1

NEW ZEALAND.

Morere† (1903, 1905).

Sodium-iodide	2·70
Total solids	1858·07

(Also sufficient free iodine to tinge the water light-brown.)

Kawhia (1903).

Sodium-iodide	0·47
Bromides	Trace
Total solids	1040·76

Mataroa (1905).

Sodium-iodide	1·41
Total solids	1879·60

Pahaua (1878; also Skey).

Magnesium-iodide	0·582
Magnesium-bromide	Traces
Iodine (free)	1·595
Total solids	1424·096

* Bal. Congress, Berlin, 1897 (quoted by Weber).
† Baths of simple type exist here.

Kopuowhara, Mahia (1885).

Magnesium-iodide	2·98
Total solids	1241·65

Whareama, Masterton (1889).

Iodides	0·81
Total solids	316·36

Kaiti, Gisborne (1902).

Sodium-iodide	4·0
Total solids	758·3

(This spring is now practically dried up.)

Ihuraua, Masterton (1911).

Sodium-iodide	1·68
Sodium-chloride	692·50
Total solids	762·50

Maranga, Napier (1911).

	Spring 1.	Spring 2.	Spring 3.	Spring 4.
Sodium-iodide	1·96	2·3	2·5	2·8
Chlorides	1367·8	1271·9	1540·0	1421·7

Raukawa, Hawke's Bay (1912).

Sodium-iodide	Trace.
Total solids	567·0

Totoro (1905).

Iodine not estimated.

Total solids	1496·0

Patangata (1902).

Potassium-iodide	0·5
Total solids	177·0

Raukumara, Waimate (1909).

Sodium-iodide	1·3
Total solids	783·6

*Helensville** (1903).

Sodium-iodide	0·03
Total solids	134·68

* Baths of simple type exist here.

*Te Puia** (1906).

Sodium-iodide	1·41
Total solids	978·69

Tarawera,* Taupo District (1908).

Sodium-iodide	0·25
Total solids	100·00

Parke's Spring, Taupo District. (Skey.)

Iodides	1·01
Total solids	200·73

Otumuheka, Taupo District. (Skey.)

Iodine not estimated.	
Total solids	13·88

Ruahine, Taupo District. (Skey.)

Iodine not estimated.	
Total solids	152·31

Orakeikorako, Taupo District. (Skey.)

Iodine not estimated.	
Total solids	84·86

Orakeikorako (Alum Cave). (Skey.)

Iodine not estimated.	
Total solids	56·47

McMurray's, Taupo District. (Skey.)

Iodine not estimated.	
Total solids	33·12

Te Hukahuka, Taupo District. (Skey.)

Iodine not estimated.	
Total solids	13·81

Burton's, Taupo District. (Skey.)
(Analysis incomplete.)

Taupiri (1913). (*Vide* also "Chalybeate Waters.")

Potassium-iodide	0·1
Total solids	98·8

* Baths of simple type exist here.

Wallingford, Wellington. (Skey.)

Iodides and bromides not estimated.	
Total solids	826·0

McLean's, Napier. (Skey.)

Iodides and bromides not estimated.	
Total solids	444·7

Sulphur Wells, Masterton (1906).

Sodium-iodide	1·5
Total solids	728·2

Mangapuaka, Dannevirke (1909).

Sodium-iodide	2·4
Total solids	851·3

Class IV.—Magnesic-sodic Muriated Waters.

These springs are cold and arise for the most part in the neighbourhood of Banks Peninsula. There are several round Lyttelton Harbour, containing from 30 grains to 50 grains per gallon of magnesium-chloride, with about 2 grains of ferrous bicarbonate. Similar, but weaker, springs also arise at Te Aroha and Paeroa.

EUROPE.

Friedrichshall.

Sodium-chloride	1680·0
Magnesium-chloride	840·0

NEW ZEALAND.

Okain's Bay (1904).

Sodium-chloride	295·5
Magnesium-chloride	264·8
Total solids	1128·9

Simple Alkaline Waters.

The principal ingredient in these waters is sodium-bicarbonate, and if sodium-chloride is present it is so only in a trifling amount. There is also generally present a considerable amount of carbonic-acid gas. Such waters are not common in this country, the only characteristic ones, so far as I am aware, being Puriri and Te Aroha.

Taken internally they act as antacids and diuretics, and promote the biliary secretion. They are useful in certain forms of gout, but are more suitable for robust than for debilitated subjects.

EUROPE.

Vichy.

Sodium-bicarbonate	350·0
Temperature	89° to 108° F.

NEW ZEALAND.

Te Aroha (1903, 1904, 1905).

Sodium-bicarbonate	657·4
Sodium-chloride	59·5
Total solids	784·3
Temperature	135° F.

Puriri. (*Vide* also "Table Waters.")

Sodium-bicarbonate	452·39
Total solids	537·11
Temperature	60° F.

Muriated Alkaline Waters.

In these waters considerable quantities of sodium-chloride are present with the bicarbonate, and, while they are useful in the same class of cases as the last, they are generally believed to be less "lowering."

EUROPE.

Ems.

Sodium-chloride	70·0
Sodium-bicarbonate	140·0
Temperature	80° to 120° F.

NEW ZEALAND.

*Waiwera.** (Skey; also 1904.)

Sodium-chloride	116·7
Sodium-bicarbonate	87·5
Total solids	219·5
Temperature	105° F.

Ohaeawai † (1904).

Sodium-chloride	65·10
Sodium-bicarbonate	134·50
Total solids	255·66
Temperature	180° F.

(This water is strongly sulphuretted, and might with equal justice be placed among the sulphur waters. For further analyses of the Ohaeawai Springs, *vide* Rep. Domin. Lab. 1909.)

* Baths of simple type exist here.
† *Cf.* Mercurial waters.

Muriated Sulphated Waters.

As already mentioned, the sulphated waters are scarcely represented in New Zealand, the only example, so far as I am aware, being the somewhat anomalous Okain's Bay water, already classed under the calcic muriated and chalybeate waters.

This water, while containing an overwhelming proportion of chlorides, contains also a moderate amount of magnesium-sulphate, any action of which, however, would be subordinate to that of the other ingredients.

EUROPE.

Brides, Salins.

Sodium-chloride	126·0
Sodium-sulphate	84·0
Magnesium-sulphate	35·0
Temperature	96° F.

NEW ZEALAND.

Okain's Bay (1904)

Sodium, magnesium, and calcium chlorides	1028·8
Magnesium-sulphate	78·0
Total solids	1128·9

(Cold spring.)

The Calcareous or Earthy Waters.

New Zealand is poor in springs of this class, calcium, when present in any quantity, being generally in the form of the chloride.

EUROPE.

Contrexéville.

Calcium-sulphate	105·0
Calcium-bicarbonate	28·0

NEW ZEALAND.

Waikoura, Kaeo (1909).

Calcium-bicarbonate	127·5
Sodium-bicarbonate	126·6
Total solids	304·1

Wairongoa. (*Vide* also " Table-waters.")

Calcium-bicarbonate	67·86
Magnesium-bicarbonate	35·89
Total solids	165·75

*Kamo.** (*Vide* also "Table-waters.")

Calcium-bicarbonate	57·68
Magnesium-bicarbonate	17·05
Sodium-bicarbonate	38·64
Total solids	164·36

Copland River, Westland (1906).

Calcium-bicarbonate	27·0
Sodium-bicarbonate	76·6
Total solids	142·3

Fox River, Westland (1906).

Calcium-bicarbonate	10·5
Sodium-bicarbonate	44·4
Total solids	79·5

Chalybeate Waters.

Therapeutically, the most important of these waters are those containing the bicarbonate of iron and free carbonic-acid gas. Many of the chalybeate springs of New Zealand contain large, and sometimes enormous, quantities of the sulphate, and, while these are noted here, they are, except as baths, of little practical use in so far as the iron-salt is concerned. The ferrous bicarbonate, on the other hand, is easily assimilated, especially when associated with carbonic-acid gas; while it is to the presence of this gas that baths of such waters owe their stimulating properties. There are baths of this nature at Kamo, but for therapeutic purposes these are unfortunately wholly undeveloped at present.

EUROPE.

Schwalbach.

Ferrous bicarbonate	5·6
Temperature	Cold

NEW ZEALAND.

Taupiri† (1913).

Ferrous bicarbonate	16·4
Total solids	98·8
Carbonic acid (free)	18·6

Waitangi, Rotoehu (1903, 1904).

Ferrous bicarbonate	0·5
Total solids	58·73
Temperature	120° F.

(Free effervescence of carbonic acid.)

* Baths of simple type exist here. † From a bore.

*Kamo.**

Oxide of iron (present in the spring as bicarbonate)	0·28
Total solids	164·36

Ohaeawai, Spring No. 1 (1909).

Ferrous sulphate	4·1
Total solids	45·6

Waikoura, Kaeo (1909).

Ferrous bicarbonate	2·9
Total solids	304·1

Soda Spring, Ngawha.

Ferrous bicarbonate	1·2
Carbonic acid (free)	35·0
Total solids	31·8

Kotuku, Greymouth (1904).

Ferrous bicarbonate	4·10
Total solids	201·25

Okain's Bay† (1904). (*Vide* also "Muriated Waters.")

Ferrous bicarbonate	26·7
Total solids	1128·9

Patangata (1902).

Ferrous bicarbonate	0·6
Total solids	176·4

Aorangi. (Skey.)

Ferrous bicarbonate	0·94
Total solids	13·75

Paeroa (1905). (*Vide* also "Table-waters.")

Ferrous bicarbonate	1·6
Total solids	167·8
Free carbonic acid	26·0
Temperature	80° F.

*Waiwera.** (*Vide* also "Muriated Alkaline Waters.")

Ferrous bicarbonate	0·686
Total solids	219·558

* Baths of a simple type exist here. † From a bore.

*Taupo Waters.**

Iron Spring, Terraces (1905).

Ferrous bicarbonate	0·28
Total solids	63·04
Carbonic acid	16·90
Temperature	120° F.

Mangapakeha (1906). (*Vide* also "Iodide Waters.")

Ferrous bicarbonate	4·00
Total solids	374·00

Soda-water Spring, Terraces (1905).

Ferrous bicarbonate	0·84
Total solids	64·19
Carbonic acid	47·70
Temperature	Cold.

Arsenic Spring, the "Spa" (1905).

Ferrous bicarbonate	0·56
Total solids	52·52

(This spring contains no arsenic.)

*Wairakei Waters.**

Devil's Eye-glass (1905).

Ferrous bicarbonate	1·20
Total solids	117·25

The Boilers (1905).

Ferrous bicarbonate	1·12
Total solids	100·77

(These last two waters are scarcely potable).

*Waiotapu.**

Chalybeate waters exist here, but so far no potable specimens have been analysed.

Rotomahana "Iodine Spring" (1904). (Contains no iodine.)

Ferrous bicarbonate	0·62
Total solids	157·79
Temperature	212° F.

Motu, Gisborne (1904).

Ferrous sulphate	44·68
Total solids	379·31

* Baths of simple type exist here.

White Island. (Skey.) (*Vide* also "Acid Waters.")

Ferrous sulphate	1059.00
Total solids	13638·00
Temperature	212° F.

Whale Island. (Pond.)

Ferrous sulphate	9·38
Total solids	250·30
Temperature	198° F.

Abbotsford, Otago (1882). (Analysis incomplete.)

Ferrous sulphate.	
Total solids	304·00

Akitio, Wellington. (Skey.)

Iron and alumina	0·93
Total solids	37·65

Onetapu. (Skey.)

Ferrous chloride not estimated.	
Total solids	456·00

Bay of Islands. (Skey.)

Iron-oxide	2·23
Total solids	134·62

Amberley, Canterbury. (Hector.)

Total solids	93·60

(Cold spring.)

Waikohu (1910).

Ferrous sulphate	1·50
Total solids	210·50

Rotorua Waters.

The majority of these contain iron, but as this is not an important and essential feature of these waters two only are given as types of the rest.

Rachel Spring (1912).

Ferrous bicarbonate	0·01
Total solids	131·34

Postmaster Spring (1906).

Ferrous sulphate	0·52
Total solids	86·81

Sulphur Waters.

This is a very important but somewhat ill-defined group, characterized by the presence of sulphides in sufficient quantity to give a very noticeable odour to the water. In Europe, as a general rule, these waters are only feebly mineralized, the other ingredients of the water being comparatively unimportant. In New Zealand, while this rule holds good for the majority of the sulphur waters, yet there is a very important class, of which the acid waters of Rotorua may be taken as a type, in which, while the sulphides are very much in evidence, other ingredients have a considerable and sometimes a very much greater importance.

As compared with the other mineral waters of New Zealand, there is an overwhelming preponderance of sulphur waters, both in the number of springs and in the amount of outflow. All are hot and all are siliceous. The great bulk of these springs arise in the volcanic region stretching from the central volcanoes of the North Island northward to the Bay of Plenty, and, indeed, right out to sea to White Island.

The vast majority of these waters have not yet been analysed, but from the great number of specimens that have already been examined a very fair estimate may be made of the whole.

It is usual to draw a distinction between those sulphur waters containing marked quantities of sodium-sulphide and those containing only sulphuretted hydrogen, and special therapeutic effects have been attributed to the former class. While admitting the distinction, it must be borne in mind that frequently the second represents only a phase of the first, and that, owing to the very rapid decomposition of sodium-sulphide on exposure to air, analysis, unless performed at the spring, is apt to show only sulphuretted hydrogen, sulphur, and sodium-carbonate.

The sulphur waters may be divided into two main classes—the alkaline or neutral, and the acid.

Class I.—The Alkaline Sulphur Waters.

For the most part the specific gravity of these waters is not high, the largest ingredients being usually silicate and chloride of sodium, and the alkalinity not strong.

For all practical purposes their most marked characteristic is the amount of silicate they contain, and it is this ingredient which gives to the alkaline waters of the Rotorua district their peculiarly bland and satiny feel, and which makes them so valuable for bath purposes. A similar condition causes the " unctuous " sensation of the *sources savonneuses* at Plombières.

For a full discussion on the action of the alkaline silicates the reader is referred to page 72.

As the highly siliceous waters shade off imperceptibly into the less siliceous, it has not seemed convenient to make them a separate class, and they are therefore all included here under the term "sulphur waters."

EUROPE.

Aachen (Aix-la-Chapelle).

Sodium-chloride	182·0
Sodium-carbonate	42·0
Sodium and hydrogen sulphides	
Temperature	113° to 133° F.

NEW ZEALAND.

Rachel Spring, Rotorua (1912).

Sodium-sulphide	10·27
Sodium-chloride	65·87
Sodium-silicate	23·78
Ferrous bicarbonate	0·01
Carbon-dioxide	9·17
Total temperature	194° F.

Under this heading come, with the exception of certain muddy geysers of the type of Waimangu, practically the whole of the springs in the "Thermal District" which exhibit, or tend to exhibit, geyser action. Thus would be included many springs at Tokaanu, the Taupo geysers, the springs of the Geyser Valley at Wairakei, and the Whakarewarewa and Ohinemutu geysers. A certain number of these are given as types of the rest.

Many of these waters contain so very little sulphide that they might with equal justice be classed under the heading of "Simple Thermal Waters," or of "Muriated Waters," but for convenience they are placed all together here.

Oil Bath,* Rotorua District. (Skey.)

Silica and silicates	29·00
Sodium-chloride	66·34
Total solids	104·54

Spout Bath,* Rotorua District. (Skey.)

Sodium-silicates	16·32
Sodium-chloride	53·61
Total solids	87·78

* The surface temperature of these springs, which exhibit more or less geyser action, is the boiling-point. Their temperature apparently increases directly as the distance below the surface at which it is taken.

Kuirau, Rotorua District. (Skey.)

Silicates	22·00
Sodium-chloride	45·70
Total solids	79·85

Te Koutu, Rotorua District. (Skey.)

Sodium-silicate	32·12
Total solids	72·78

Waihunuhunukuri (Lake House), Rotorua District. (Hector.)

Total solids	58·40

Waikite,* Rotorua District (1904).

Sodium-chloride	38·75
Sodium-bicarbonate	20·03
Silica	24·36
Total solids	90·28

Matuatonga,* Rotorua District. (Hector.)

Sodium-chloride	66·44
Sodium-silicate	29·27
Total solids	113·27

Hanmer,† South Island (1912):

Sodium-chloride	75·37
Sodium-borate	25·10
Sodium-sulphide	2·07
Total solids	116·75

Crow's Nest Geyser,* Taupo District. (Hector.)

Total solids	153·6

Witches' Cauldron,* Taupo District. (Hector.)

Total solids	166·4

Waiariki, Taupo District. (Hector.)

Total solids	86·4

Top Spring, Terraces, Taupo District (1905).

Sodium-chloride	43·66
Total	105·80
Temperature	184° F.

* The surface temperature of these springs, which exhibit more or less geyser action, is the boiling-point. Their temperature apparently increases directly as the distance below the surface at which it is taken.

† The amount of H_2S present is so small that this water might with equal justice be classed under the heading of "Muriated Waters," or of "Borated Waters."

South Bay Spring, Terraces, Taupo District (1905).

Sodium-chloride	56·10
Total	107·72
Temperature	180° F.

A.C. Bath, Spa, Taupo District (1905).

Total	46·43
Temperature	102° F.

Old Sulphur Spring, Spa, Taupo District.

Total	63·79
Temperature	135°F.

Champagne Pool,* Wairakei (1905).

Sodium-chloride	195·20
Total	242·68

Red Coral Geyser,* Wairakei (1905).

Sodium-chloride	39·35
Total	100·77

Champagne Pool, Waiotapu.

Sodium-chloride	220·4
Carbonic acid (free)	13·2
Total solids	288·2
Temperature	212° F.

Omupokapoka, Onepu (1904).

Total constituents	116·82
Temperature	180° F.

Manupirua, Rotoiti (1904).

Total solids	44·91
Temperature	105° F.

Class II.—Acid Sulphur Waters.

With the exception that they are much more siliceous, the alkaline sulphur waters bear a fairly close resemblance to numerous sulphur waters in Europe; but for a type of the acid sulphur waters we have to look to America, there being no waters of this nature used at the European spas.† The nearest European approach to the acid baths of New Zealand is to be found in the

* The surface temperature of these springs, which exhibit more or less geyser action, is the boiling-point. Their temperature apparently increases directly as the distance below the surface at which it is taken.

† Strongly acid waters are found in the Yellowstone Park, U.S.A., one spring containing over 40 per cent. sulphuric acid. There is also an acid spring at Tuscarora, Canada.

" peat baths " of Austria, which contain free sulphuric and formic acids and sulphate of iron.

For a detailed account of the physiological and therapeutical action of these waters the reader is referred to pages 78–83.

Rotorua Acid Waters.

—	Postmaster Bath Spring (1906).	Priest Bath Spring (1906).	Sulphur Point Effervescing Spring (1906).	Spring supplying New Baths.
Sodium-sulphate ..	14·25	10·85	18·10	19·94
Aluminium-sulphate ..	15·60	9·60	8·10	12·38
Silica	15·10	12·10	20·20	22·82
Sulphuric acid (free) ..	22·29	3·77	4·46	16·80
Carbonic acid (free) ..	28·84	40·00	2·52	4·31
Sulphuretted hydrogen	13·09	5·00	0·19	1·80
Total	128·74	97·49	81·95	102·58
Temperature ..	110° F.	105° F.	160° F.	150° F.

There are innumerable springs in the central Rotorua group, along the foreshore of Lake Rotorua, which conform to the type of the Priest and Postmaster springs. Of these the first two on the following list may serve as examples :—

Waikupapapa.

Hydrochloric acid (free)	7·49
Sulphuric acid (free)	4·29
Total solids	56·45

Ngaruapuia.

Hydrochloric acid (free)	6·76
Sulphuric acid (free)	3·11
Total solids	59·50

Taheke, Rotoiti (1908).

Sulphuric acid (free)	152·0
Total solids	231·0

Horakikimumuru, Rotoiti (1908).

Sulphuric acid (free)	68·6
Total solids	130·5

White Island and Whale Island, in the Bay of Plenty, contain springs of remarkable acidity, which are not used as baths.

White Island. (Skey.)

Hydrochloric acid (free)	9547·0
Total solids	13638·0
Temperature	212° F.

*White Island Lake** (1910). (*Vide* also "Arsenical Waters.")

Aluminium sulphate	1476·3
Hydrochloric acid (free)	3383·6
Total solids	6469·6
Temperature	110° F.

Whale Island. (Pond.)

Sulphuric acid	138·32
Total solids	250·30
Temperature	198° F.

Abbotsford, Otago (1882).

Sulphuric acid (free, and combined with iron)	191·87
Total solids	304·01

TAUPO.

Rotokawa (*Black Water*). (Hector.)

Hydrochloric acid (free).	
Total	142·4
Temperature	192° F.

Rotokawa (*Yellow Water*). (Hector.)

Hydrochloric acid (free).	
Total	176·0
Temperature	152° F.

* The composition of this water would appear to vary very considerably. Probably samples taken from various portions of the lake would vary according to their distance from the main spring, and, indeed, there are probably a large number of springs of various composition feeding the lake. Again, the analysis may probably vary from year to year in accordance with varying volcanic activity. The last analysis (1910) is given in full in percentages, as it not only shows this variation, but is remarkable for showing the presence of pentathionic acid, formed by the inter-action of H_2S and SO_2, a body not previously detected in mineral waters (Maclaurin):—

	Per Cent.		Per Cent.
Ammonium-chloride ..	0·02730	Copper-sulphate ..	Trace.
Potassium-chloride ..	0·16540	Molybdic acid ..	Trace.
Sodium-chloride ..	0·03790	Silica	0·00800
Potassium-bromide ..	0·00510	Titanium-dioxide ..	0·00300
Potassium-iodide ..	Trace.	Boron-trioxide ..	0·03100
Sodium-sulphate ..	0·61910	Arsenious oxide ..	0·00056
Magnesium-sulphate ..	0·39480	Carbon-dioxide ..	0·01300
Calcium-sulphate ..	0·50900	Hydrochloric acid ..	4·83380
Aluminium-sulphate ..	2·10900	Pentathionic acid ($H_2S_5O_6$)	0·02400
Ferric sulphate ..	0·26000		9·24236
Ferrous sulphate .	0·19760		
Manganous sulphate ..	0·00380		

WAIRAKEI.

Practically all springs of the Kiriohinekei Valley are more or less acid : two are given as types.

Devil's Eye-glass (1905). (*Vide* also " Chalybeate Waters.")

Sulphuric acid (free)	2·80
Carbonic acid (free)	7·10
Total solids	117·25

The Boilers (1905). (*Vide* also " Chalybeate Waters.")

Sulphuric acid (free)	4·50
Carbonic acid (free)	7·50
Total solids	100·77

Sulphur Terrace, Waiotapu (1909).

Sulphuric acid (free)	2·5
Total solids	43·6
Temperature	212° F.

Class III.—Muddy Waters.

There remains a subclass of the sulphur waters which consists of mineral water containing large quantities of highly siliceous mud in suspension. The importance of these waters lies in the fact that they are sometimes utilized for mud baths.

Some of them contain free mineral acids, others are neutral, or only give an acid reaction from the amount of free carbonic-acid gas they contain. Typical examples of the former are the Coffee-pot and the Cameron Springs, and of the latter the Sulphur Point Mud Spring, all of Rotorua

Coffee-pot.

Sodium-sulphate	23·71
Hydrochloric acid (free)	7·66
Sulphuric acid (free)	7·60
Total	60·19

Cameron.

Sodium-sulphate	44·54
Hydrochloric acid (free)	5·92
Total	80·50

Sulphur Point (1906).

Sodium-chloride	80·85
Sodium-silicate	26·30
Carbonic acid (free)	14·90
Total	141·72

Below is given an analysis (1906) of the muddy deposit around this spring, from which and from similar material the mud baths of Rotorua principally are made. It consists mainly of silica, and

is noticeable in containing both gold and silver. On account of its interest I have given Dr. Maclaurin's analysis in full.

Silica ..	.. 69·30	Soda and potash..	1·30
Alumina	.. 4·52	Sulphur (combined)	1·40
Iron-oxides	.. 2·00	Sulphur (free) ..	6·09
Titanium-oxide ..	0·58	Organic matter ..	10.01
Lime ..	.. 1·00	Water	3·70
Magnesia	.. 0·10		

" Microscopic examination of the deposit showed that it consisted mainly of quartz and amorphous silica, with a little feldspar. The mud also contains 5 grains of gold and 6 dwt. 1 grain of silver per ton."

Arsenical Waters.

There are no springs containing arsenic used for therapeutic purposes in New Zealand. Several springs contain traces of arsenic; others again reputed to do so, such as the Arsenic Spring in the Spa grounds at Taupo, contain none at all.

There is one spring, however, so huge and so rich in arsenic as to completely dwarf all the arsenical springs of Europe put together. This is the hot acid lake on White Island, some 15 acres in extent (*vide* " Acid Sulphur Waters"). The waters are, however so highly mineralized as to be unfit for either internal or external medication.

EUROPE.

La Bourboule.

Sodium-arseniate	1·96
Total solids	448·00

NEW ZEALAND.

White Island Lake (1910).

Arsenious oxide	3·92
Total solids	6469·65

Burton's Taupo. (Hector.)
(Traces of arsenic.)

Borated Waters.

Salts of boron are not usually found in appreciable quantities in mineral waters, and but scanty references to borated waters can be found in the text-books. Traces of borate are present in the waters of Baden (Switzerland), but appear to be of no therapeutic importance. In several New Zealand waters, however, the salt is present in considerable quantities, and has a marked influence on therapeutic effects. For a full discussion of the subject the reader is referred to the chapter on Hanmer.

Hanmer (1913).

Sodium-borate	25·10
Total solids	116·75

Taupo Magnesia Spring (1913).

Sodium-borate	5·28
Total solids	130·05

Puketitiri, Napier (1913).

Sodium-borate	4·33
Total solids	33·52

White Island Lake (1910).

Boron-trioxide	21·7
Total solids	6469·6

Mercurial Waters.

Certain of the muriated alkaline springs are turbid with mud containing varying amounts of mercury derived from the soil around, which is rich in this mineral. While such can perhaps hardly be strictly classed as "mercurial mineral waters," the natural mixture of mineral water with mercurialized mud is obviously important from a therapeutic point of view, and is classed here for convenience. The baths, which consist merely of the natural hot pools and surrounding mud, have been utilized in the treatment of scabies, but not yet, so far as I am aware, in that of syphilis.

*Ohaeawai** (1904). (*Vide* "Muriated Alkaline Waters.")
Amount of mercury variable. Temperature, 180° F.

Table-waters.

This is another ill-defined group of waters, usually characterized by feeble mineralization and by containing a large quantity of free carbonic-acid gas. It is obvious that such a water may be classed under one or other of the previous headings according to the preponderating ingredients it may contain, and, as a matter of fact, most of the mineral waters used as table-waters in New Zealand are really so strongly mineralized as to justify the title of "medicinal," and almost all contain rather more iron than is consistent with an ideal table-water

EUROPE.

Selters (Seltzer water).

A muriated alkaline water containing sodium-chloride	140·0

* Minute globules of mercury are easily discernible to the naked eye in the deposit alongside the springs.

NEW ZEALAND.

Wairongoa (South Island). *Vide* also "Earthy Waters.")

Calcium-bicarbonate	67·86
Magnesium-bicarbonate	35·89
Sodium-chloride	22·73
Sodium-bicarbonate	20·91
Sodium-sulphate	14·70
Total solids	165·75

Together with a large excess of carbonic-acid gas, which is bottled with the water.

Puriri. (*Vide* also "Alkaline Waters.")

This is a cold alkaline spring, temperature 60° F., which is very freely used as a table-water, but which is so strongly mineralized that it should really be classed under the head of "Alkaline Waters."

Te Aroha. (*Vide* also "Muriated Alkaline Waters.")

The thermal waters of Te Aroha, cooled and artificially aerated, are also sometimes used as table-waters, but are so strongly mineralized as to really constitute medicinal waters.

There are also at Te Aroha several cold springs, feebly mineralized, pleasant to the taste, but somewhat deficient in natural carbonic-acid gas.

Cold Magnesia Spring (1902).

Calcium-bicarbonate	41·5
Magnesium-bicarbonate	23·4
Total solids	83·6

Carbonic-acid gas variable in amount.

Kamo. (*Vide* also "Chalybeate Waters.")

These waters are tepid to warm, strongly effervescent with carbonic-acid gas, and pleasant to the taste.

Calcium-bicarbonate	57·68
Sodium-bicarbonate	38·64
Sodium-chloride	38·01
Total solids	164·36

Paeroa (1905). (*Vide* also "Chalybeate Waters.")

Tepid spring, temperature 80° F., fair effervescence of CO_2, pleasant sweetish taste.

Magnesium-bicarbonate	73·0
Sodium-bicarbonate	39·4
Calcium-bicarbonate	35·5
Total solids	167·8
Free carbonic acid	26·0

CHAPTER XI.

THE SECONDARY SPAS.

The vast majority of the springs in the above list are practically unequipped and almost unused. Perhaps the only places that could be dignified with the name of "spa" are the three under Government management—viz., Rotorua, Te Aroha, and Hanmer. At Rotorua and Hanmer, in addition to the bathing establishments, there are mineral-water hospitals, with resident medical officers, for the convenience of the hospital class of patients. There are baths, for the most part of the simple immersion type, with hotel accommodation alongside, at Kamo, Waiwera, Helensville, Waingaro, Okoroire, Waiotapu, Wairakei, Taupo, Tokaanu, Tarawera, Morere, and Te Puia.

The North of Auckland Spas.

Kamo, just outside Whangarei, to which a regular boat service runs from Auckland, has a mild climate and springs of unique value. There are two large springs arising in the hotel gardens, and several smaller ones; indeed, small springs are to be met with over a considerable area of the surrounding limestone country. The waters are of a mild chalybeate calcareous nature, quite palatable, and freely effervescent with carbonic acid.

The two main springs are used—one for bottling the waters and the other for baths—and both foam vigorously with gas, more especially the bathing-spring. The amount of gas given off varies considerably from day to day, and indeed is sometimes evolved so vigorously as to make bathing decidedly dangerous. The principal bath is constructed actually in the spring, which certainly gives the maximum therapeutic effects, but, on the other hand, is by no means free from risk of asphyxiation to the bather.

The water being below the "indifferent temperature" of the skin, on first entering the bath there is a slight sensation of chilliness: as, however, the bubbles of carbonic-acid gas begin to coat the skin, this sensation is replaced by one of increasing warmth and tingling (see the remarks on the indifferent temperature of gases, page 14). A contraction of the muscular fibres in the skin takes place, notably of the dartos, a contraction so vigorous as to become positively painful, and the scrotum is reduced to less than half its usual bulk. The result of the bath is a marked briskening of the circulation from active cutaneous hyperæmia (see page 20), and a general sense of exhilaration.

In addition to the natural bath, there are several private baths of artificially heated water. Unfortunately, the precautions for heating the water in the actual bath adopted at Nauheim have not been observed, and as a result the carbonic-acid gas is largely expelled before reaching the bather, and the ferrous carbonate dissolved in the water is in great measure precipitated as oxide. For therapeutic purposes the baths are thus greatly spoilt.

Indications.—When proper precautions have been adopted for safeguarding the invalid, the natural bath should prove invaluable in the treatment of valvular heart-disease with failing compensation, but at present it is hardly suitable Cases of anæmia and debility should do well with a combination of baths and drinking the waters—*i.e.*, one bath a day and four tumblerfuls of water fresh from the spring. Cases of mild varicocele and sexual debility should also greatly benefit.

Analysis.

	Grains per Gallon.
Calcium-bicarbonate	57·68
Sodium-bicarbonate	38·64
Sodium-chloride	38·01
Oxide of iron (present as bicarbonate) ..	0·28
Total solids	164·36
Temperature	78° F.

Waiwera, thirty miles north of Auckland, can be reached by either road or boat. The warm alkaline springs arise on the sea-beach at a temperature of 105° F. There are several private and public immersion baths, but no serious attempt has been made to cater for the invalid. Waiwera, however, enjoys a mild equable climate, and frosts are rare and never severe, so that as a winter resort for those requiring a mild sedative climate the place has great possibilities, more especially as the situation is charming. The winter rainfall, however, is sometimes heavy, and this, together with a lack of amusements, constitutes rather a serious drawback.

Indications.—The waters are of a mild muriated alkaline type, and are especially indicated in certain gastric and pulmonary conditions—*e.g.*, chronic gastric catarrh and chronic bronchitis. They are less "lowering" than the Te Aroha waters, as they contain less sodium-bicarbonate and a large proportion of chloride. A muriated alkaline water tends to increase the secretory activity of the gastric mucous membrane,* and is indicated in gastric hypoacidity. Again, such waters tend to liquefy bronchial secretion,

* *Cf.* the experiments of Bickel, Berliner Klin. Wockenshrift, 1906, No. 2.

and thereby assist expectoration, an action which the mild salt-laden atmosphere would also aid. Altogether, I would point out that, for selected cases, Waiwera has not attracted the attention it deserves.

Analysis.	Grains per Gallon.
Sodium-chloride	116·7
Sodium-bicarbonate	87·5
Ferrous bicarbonate	0·6
Total solids	219·5
Temperature	105° F.

Helensville, on the west coast, is approached by rail from Auckland. The springs arise on flat ground, practically at the sea-level, a mile or so out of the town, and the supply of water has recently been greatly augmented by boring. Recently, too, a modest bathing establishment of ten private baths and a public swimming-bath has been erected, and some effort has been made to attract invalids. Public gardens and playing-lawns have been laid out and accommodation provided alongside the springs. No balneological appliances, however, are as yet available, so that it is as a drinking, perhaps, rather than as a bathing establishment that Helensville can at present base its claims to medical attention. The waters are muriated and contain also appreciable quantities of sodium-iodide, though the latter is in small amount as compared with that of the Poverty Bay springs.

Indications.—The waters are indicated in chronic dyspepsia with hypo-acidity, especially if associated with hepatic engorgement and piles. Similar waters in Europe, containing small quantities of iodide, are given in cachectic and syphilitic conditions. Though the amount of iodide present is small, it should be very perfectly ionized, and it is difficult to compare doses of a salt dissolved in a natural water and those in an artificial solution (compare page 11). A combination of bathing and drinking the waters is also indicated in the chronic gouty and "rheumatic" (see discussion on page 91) conditions, and in some bronchial cases.

Analysis.	Grains per Gallon.
Sodium-chloride	114·46
Sodium-iodide	0·03
Total solids	134·68
Gases H_2S and CH_4.	
Temperature	115° to 146° F.

The Waikato Spas.

The springs of this district are "simple thermal" waters of low specific gravity, the best known being at Okoroire.

Okoroire, on the Rotorua branch railway, consists of one fairly large hotel alongside three or four primitive but pleasant baths, on the banks of the Waihou River. The waters, being distinctly siliceous, have a characteristic tempting appearance and pleasant feel in a bath (for analysis see page 112), but no balneological appliances, douches, &c., are available.

Indications.—Okoroire, with its pleasant mild climate and simple baths, its pretty trout-stream, and golf-links, is a place for the quiet holiday-seeker rather than the true invalid. At the same time, mild arthritic cases undoubtedly benefit, and cases of chronic gastric catarrh may do better than at a more potent spring. For the latter cases a tumblerful of the water should be drunk fresh and hot from the spring three or four times a day, on an empty stomach. The warm bland fluid will flush the stomach and bowel, while the silicate will exert a very mild antiseptic action (see page 72).

Matamata, a few miles distant, on the same line of railway, has closely similar springs, but with the sodium-chloride replaced by bicarbonate (analysis, page 112). The simple immersion baths are a good deal used locally, but are practically unknown outside the district. The water should be a pleasant corrective in chronic dyspepsia, and, if drunk in large quantities, as an alkaline flush of the urinary system.

Waingaro, on the coach-road from Ngaruawahia to the west coast, has waters of the most strictly "indifferent" type, containing only 22 grains of solids. The outflow, however, is very large and the temperature high. There is a large simple immersion bath, with hotel accommodation alongside (analysis, page 112).

Hot Lakes District.

The principal spa, Rotorua, has been already dealt with, but baths in simple form exist at Waiotapu, Wairakei, and Taupo. In addition, countless springs in the district—*e.g.*, Manupirua and Taheke, at Rotoiti—have considerable therapeutic reputation amongst the Maori population, who use them freely as baths.

Waiotapu, twenty-one miles from Rotorua, on the Taupo Road, boasts an enormous number of springs, some of which have an equally enormous outflow. All the waters are sulphurous and evolve more or less sulphuretted hydrogen, with the addition in some cases of free carbonic acid (see analysis, page 131). They may all, for convenience, be classed under the heading of "Sulphur

Waters," but there are considerable and radical differences of character between the different springs. Thus there is a large group characterized by feeble mineralization and containing a small quantity of sodium-chloride, of which the Roadman's Bath may be taken as a type (see page 113). Another subclass, of which the Champagne Pool is the principal example, is richer in salts, and, in addition, contains large amounts of free carbonic-acid gas (see page 131). A third subclass exhibits free sulphuric acid (see Sulphur Terrace Spring, page 134). A fourth subclass is highly aluminous.

Other waters offer striking physical contrasts of colour, in some cases due to precipitation of sulphur, in others to the presence of iron-salts, but in numberless others to causes as yet not accurately determined. In addition to the mineral waters, there are hot-mud springs of enormous proportions (compare the fango baths of Rotorua, page 83), fumaroles, and solfataras, and even petroleum springs.

With all this wealth of material there are only one or two baths of the most primitive description, so that Waiotapu at present can be reckoned as only a potential spa.

Wairakei, thirty miles beyond Waiotapu, is again a tourist centre rather than a spa, and is famed more for its beautiful and fastastic geysers than for the therapeutic virtue of its springs. This is not because of any lack of therapeutic value in the waters, but simply because, from want of development, the waters are, so to speak, lying fallow. The springs here are all "sulphur waters," and all siliceous and intensely hot, but, as at Waiotapu, they group themselves into subclasses. Thus all the waters of the Geyser Valley are "muriated" (see Champagne Pool, page 131), while those of the Kiriohinekei Valley contain sulphuric acid (see "The Boilers," page 126).

The baths, which are alongside the hotel, are very primitive, but equally pleasant.

Taupo is, again, chiefly a tourist resort, and no serious attempt has yet been made to cater for the invalid, and no skilled medical advice is available. There is the same bewildering profusion of mineral waters as at Waiotapu and Wairakei, the waters in the main, with the exception of some borated waters, conforming to the same types.

The principal baths are in the grounds of the "Spa" and of the Terraces Hotel, some two miles distant. The "Spa" lies in a sheltered garden hidden in a steep-walled hollow below the surface of the surrounding plain. In consequence of its sheltered position and the number of hot springs, the climate of this little valley is very much milder than that of Taupo generally. The Terraces Hotel, on the other hand, stands a couple of hundred feet higher,

and enjoys a dry bracing climate, while, immediately alongside, the baths lie in a garden in a deep ravine whose climate resembles that of the "Spa." These contrasting climates should be borne in mind when ordering convalescent patients to Taupo, as a tonic or sedative climate can be selected at will (for analysis of waters see pages 126, 130, 131).

Tokaanu, on the south side of Lake Taupo, contains numerous hot springs closely resembling those of Taupo and Wairakei. There is a concrete public immersion bath available, but no balneological appliances, and the place is a tourist rather than an invalid resort.

Napier and Gisborne Districts.

Tarawera, on the Taupo–Napier Road, has hot springs of no great magnitude, simple immersion baths, and hotel accommodation. The waters are of the muriated type, and contain 0·25 grains of sodium-iodide to the gallon. No balneological appliances or medical supervision are available.

Analysis.	Grains per Gallon.
Sodium-chloride	80·00
Sodium-iodide	0·25
Total solids	100·00

Morere, on the east coast, between Gisborne and Napier, has hot springs which in some respects may be considered among the most interesting and important in the country. The waters are of high specific gravity, containing large quantities of both sodium and calcium chloride, but their chief interest centres in the unusually large amount of iodine present, chiefly as sodium-iodide, but to a certain and varying extent as free iodine. The springs arise in the bed of a small torrential creek, a circumstance which renders the collection and use of the waters at times somewhat difficult. At the actual sources, free iodine would appear to be almost if not quite absent, but a short distance away, especially when the water has been allowed to fall in douche form into the baths, some decomposition of the iodide appears to take place, and iodine makes its presence known in sufficient quantities to be appreciated by its pungent smell and to colour the water pale-brown. This iodine, being practically nascent, should have most active therapeutic properties, and I am convinced that at some future date, when the springs become more accessible and better known, they will become famous. At present, however, little or no facilities for treatment exist. Some simple immersion baths are being constructed, and accommodation for visitors is available near at hand,

but no special hydro-therapeutic apparatus is provided, and there are no resident medical men or skilled attendants.

Indications.—As already mentioned, the stage of development of the spa hardly warrants the medical attendant advising other than local patients to take a course of baths and waters. But in view of the now well-known very potent nature of even minute quantities of iodine in organic combination, and of the alterative action of iodide of sodium, it can hardly be doubted that, in addition to ordinary arthritic cases, many patients requiring tonic alterative treatment, and especially patients suffering from tuberculous glands, will derive great benefit here as soon as proper facilities exist.

Analysis	Grains per Gallon.
Sodium-chloride	1249·67
Calcium-chloride	594·78
Sodium-iodide	2·70
Free iodine (variable).	
Total solids	1899·60
Temperature	120° F.

Te Puia, north of Gisborne, on the same coast road as Morere, has springs of a closely similar nature, but weaker both in total salts and in iodide. The baths here are still exceedingly primitive; but, as a well-built cottage hospital exists close to the springs, it will probably not be very long before the waters are actively exploited. In addition to the springs, Te Puia is noteworthy for the large amount of free carburetted hydrogen evolved not only from the springs, but from clefts in the surrounding rocks. In view of the utility of this gas for domestic purposes, it will probably aid materially in the future development of the spa.

Indications.—As for Morere.

Analysis.	Grains per Gallon.
Sodium-chloride	807·75
Calcium-chloride	153·40
Sodium-iodide	1·41
Total solids	978·60
Temperature	150° F.

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